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FINAL QUALITY ASSURANCE PROJECT PLAN ADVANCED GEOPHYSICAL
CLASSIFICATION FOR MUNITIONS RESPONSE REMEDIAL INVESTIGATIONS ATLANTIC
FLEET WEAPONS TRAINING AREA VIEQUES ISLAND PUERTO RICO
11/1/2016
CH2M HILL

Final

**Quality Assurance Project Plan
Advanced Geophysical Classification for
Munitions Response Remedial Investigations**

**Atlantic Fleet Weapons Training Area – Vieques
Former Vieques Naval Training Range and
Former Naval Ammunition Support Detachment
Vieques, Puerto Rico**

Contract Task Order 019

November 2016

Prepared for

**Department of the Navy
Naval Facilities Engineering Command Atlantic**

Under the

**NAVFAC CLEAN 8012 Program
Contract N62470-11-D-8012**

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Executive Summary

This Advanced Geophysical Classification (AGC) for Munitions Response (MR) Remedial Investigations (RIs) Quality Assurance Project Plan (QAPP), hereafter referred to as the QAPP, supports the MR activities being performed at the former Vieques Naval Training Range (VNTR) and former Naval Ammunition Support Detachment (NASD), Vieques, Puerto Rico. This QAPP is intended to be the primary work-planning document for the use of AGC supporting RIs performed at the former VNTR and former NASD in relation to the identification of potential munitions and explosives of concern (MEC). This QAPP is intended to serve as an addendum to separate Uniform Federal Policy Sampling and Analysis Plans (UFP-SAPs), and only addresses activities associated with the use of AGC for these plans. AGC use for MR RI activities will be conducted in accordance with this QAPP, the Master Sampling and Analysis Plan (SAP), East Vieques Terrestrial UXO Sites (CH2M, 2013), and Addendum 4, Master Sampling and Analysis Plan, UXOs 3, 5, 6, and 11 Remedial Investigation (CH2M, 2016). The activities being performed in accordance to this document are limited to preferentially selecting targeted locations for intrusive investigation and subsequent munitions constituent (MC) sampling. As this is not a removal/remedial action, AGC with the intent of identifying anomaly locations that do not require removal is not a project objective.

Vieques Island has a land area of approximately 33,000 acres, and is located in the Caribbean Sea approximately seven miles southeast of the eastern coast of the main island of Puerto Rico (**Figure ES-1**). The former VNTR is located on the eastern half of the island of Vieques and the former NASD is located on the western one-third of the island, with the communities of Isabel Segunda and Esperanza located in between. On February 11, 2005, Vieques was placed on the National Priorities List (NPL) by the United States Environmental Protection Agency (EPA).

East Vieques (Former VNTR)

The former VNTR, which comprises approximately 14,600 acres, provided ground warfare and amphibious training for Marines, naval gunfire support training, and air to ground training. The former VNTR is divided into four separate operational areas as shown on **Figure ES-2**, geographically moving from west to east these areas are the:

- Eastern Maneuver Area (EMA)
- Surface Impact Area (SIA)
- Live Impact Area (LIA)
- Eastern Conservation Area (ECA)

On April 30, 2003, the former VNTR was transferred to the Department of the Interior (DOI) to be operated and managed by the United States Fish and Wildlife Service (USFWS) as a National Wildlife Refuge pursuant to Section 1049 of the National Defense Authorization Act for Fiscal Year 2002 (Public Law 107–107). Approximately 900 acres of the former VNTR, consisting of the LIA, is managed as a wilderness area where public access is prohibited in accordance with Public Law 106–398 and Public Law 107–107.

DOI developed a Comprehensive Conservation Plan (CCP) in 2007 for the Vieques National Wildlife Refuge that outlines its concept for managing the refuge (DOI, 2007). Environmental restoration of the former VNTR is based on potential risks to human health and the environment identified via the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process, together with applicable or relevant and appropriate requirements (ARARs), with consideration given to the future land use identified in the CCP.

West Vieques (Former NASD)

On April 30, 2001, the 8,114-acre former NASD on the west side of Vieques was apportioned and transferred to the DOI, the Municipality of Vieques (MOV), and the Puerto Rico Conservation Trust (PRCT) in accordance with

Public Law 106–398 (**Figure ES-3**). The property owned by DOI (approximately 3,158 acres) is managed by USFWS as part of the Vieques National Wildlife Refuge. Like the former VNTR, environmental restoration of the former NASD is based on potential risks to human health and the environment identified via the CERCLA process, together with ARARs, with consideration given to the planned future land use.

Objective and Overview of Use

The objective of using AGC at the former VNTR and former NASD is to assist in characterizing the nature and extent of MC, if present, in the subsurface. Without the use of AGC, conventional digital geophysical mapping (DGM) is performed to identify locations of subsurface metal objects and a subset of these locations must be investigated to meet the RI objectives. Soil sampling for MC is only performed where munitions items are recovered, and a minimum number of soil samples are required (specified in the SAP). Thus preferential selection of locations most likely to be a munitions item (or ‘target of interest’ [TOI]) will allow the objectives of the RI to be met using fewer intrusive investigations. This will allow for an accelerated schedule while meeting the project goals.

A modified approach to AGC will be utilized under this QAPP to decrease the total number of anomalies requiring intrusive investigation during MC investigations by allowing preferential selection of TOI. Because these investigations are not part of removal actions, these data are not being used to classify targets as TOI or non-TOI, they are only being used to create a preliminary prioritized list that will be used to preferentially select targets that are likely buried munitions.

The elements of AGC that are required to advance from the preliminary prioritized list to derive a final prioritized list (and classify targets as ‘TOI’ or ‘non-TOI’) include performance of analyst calibration digs, threshold verification digs, and validation digs. These elements are not required to meet the objectives of this investigation and will not be performed. Note that all activities leading up to the generation of the preliminary prioritized list will be conducted such that the data will support full AGC once the remaining elements are performed.

An advanced electromagnetic induction (EMI) sensor known as the TEMTADS 2x2 (TEMTADS) will be used to 1) perform dynamic surveys to detect subsurface metallic items that are potential TOI and 2) perform static cued investigations in support of geophysical classification of each selected target so that the targets may be ranked in a prioritized list where the highest priority targets are those deemed to be most likely TOI. Additionally, the dynamic geophysical detection surveys may be performed with a Geonics, Ltd. EM61-MK2 (EM61) followed by a static cued investigation using advanced EMI technology.

The general activities to be performed by CH2M to accomplish the aforementioned objective include:

1. Conduct dynamic geophysical surveys in areas accessible to global positioning system (GPS) using the TEMTADS or the EM61, to detect metallic items in the subsurface that may be TOI (e.g., munitions).
2. Perform Advanced Detection on the dynamic TEMTADS data set to identify anomaly sources that are potential TOI (Advanced Detection cannot be performed on data collected with the EM61). Unlike conventional Amplitude Response analysis, where all anomalous responses above a set threshold are targeted, Advanced Detection is a process that uses the rich data set available from advanced EMI sensors to select targets¹ based upon the anomaly *source* characteristics (size and wall-thickness). This method significantly reduces effort expended investigating anomalies caused by sources that are too small or too thin-walled to be viable TOI.

¹ Note that the term ‘target’ can refer to an anomaly peak location (from conventional ‘amplitude response’ detections) or an ‘anomaly source’ location derived from ‘advanced detection’ target selection methodology.

3. Perform cued interrogation of targets identified in the dynamic survey to create a preliminary prioritized list. Cued interrogation involves using the TEMTADs in static mode and analysis of the static data using purpose built geophysical classification software. This software derives extrinsic parameters (location and orientation) and intrinsic parameters (related to the target shape) and compares the intrinsic parameters to those of a site-specific library of candidate munitions. Based upon this comparison, a prioritized dig list is derived with the closest matches to munitions at the top of the list.

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Resumen Ejecutivo

Este Plan de Control de Calidad del Proyecto (QAPP, por sus siglas en inglés) para la Clasificación Geofísica Avanzada (AGC, por sus siglas en inglés) para las Investigaciones para la Remediación (RIs, por sus siglas en inglés) de Respuesta a Municiones (MR, por sus siglas en inglés), que de aquí en adelante se referirá como QAPP, apoya las actividades MR que se están llevando a cabo en el antiguo Campo de Adiestramiento Naval de Vieques (VNTR, por sus siglas en inglés) y en el Antiguo Destacamento de Apoyo a Municiones Navales (NASD, por sus siglas en inglés), Vieques Puerto Rico. El objetivo de este QAPP es servir como el documento principal para la planificación de trabajos que utilicen AGC para apoyar los RIs que se realizan en el antiguo VNTR y el antiguo NASD relacionados a la identificación de municiones y explosivos de preocupación (MEC, por sus siglas en inglés) potenciales. Este QAPP tiene la intención de servir como un anejo a los Planes de Política Uniforme Federal para Muestreo y Análisis (UFP-SAPs, por sus siglas en inglés), y solamente atiende las actividades asociadas con el uso de AGC para estos planes. El uso de AGC para las actividades de MR para las RI se llevará a cabo de acuerdo con este QAPP, el Plan Maestro de Muestreo y Análisis (SAP, por sus siglas en inglés), Sitios UXO Terrestres en el Este de Vieques (CH2M, 2013), y el Anejo 4 al Plan Maestro de Muestreo y Análisis para la Investigación para la Remediación de UXOs 3, 5, 6 y 11 (CH2M, 2016). Las actividades que se realizan de acuerdo a este documento son limitadas a localidades específicas preferencialmente seleccionadas para llevar a cabo investigaciones intrusivas y el muestreo subsecuente de compuestos de municiones (MC, por sus siglas en inglés). Ya que ésta no es una acción de remoción/remediación, identificar las localizaciones con anomalías que no requieren remoción no es un objetivo del proyecto.

La Isla de Vieques tiene un área terrestre de aproximadamente 33,000 acres, y se localiza en el Mar Caribe, aproximadamente siete millas al sureste de la costa este de la isla principal de Puerto Rico (**Figura ES-1**). El antiguo VNTR se ubica en la mitad este de la isla de Vieques y el antiguo NASD se ubica en la tercera parte al oeste de la isla, con las comunidades de Isabel Segunda y Esperanza ubicadas en el medio. El 11 de febrero de 2005, Vieques fue añadida a la Lista de Prioridades Nacionales (NPL, por sus siglas en inglés) por la Agencia de Protección Ambiental de los Estados Unidos (EPA, por sus siglas en inglés).

Este de Vieques (Antiguo VNTR)

El antiguo VNTR, el cual se compone de aproximadamente 14,600 acres, proveyó adiestramiento con armas sobre el terreno y adiestramientos anfibios para los Infantes de Marina. El antiguo VNTR está dividido en cuatro áreas operacionales separadas como se muestra en la **Figura ES-2**, geográficamente, de oeste a este estas áreas son:

- Área de Maniobras del Este (EMA, por sus siglas en inglés)
- Área de Impacto en la Superficie (SIA, por sus siglas en inglés)
- Área de Impacto con Bala Viva (LIA, por sus siglas en inglés)
- Área de Conservación del Este (ECA, por sus siglas en inglés)

El 30 de abril de 2003, el antiguo VNTR fue transferido al Departamento del Interior (DOI por sus siglas en inglés) para ser operado y manejado por el Servicio de Pesca y Vida Silvestre de los Estados Unidos (USFWS por sus siglas en inglés) como un Refugio Nacional de Vida Silvestre de acuerdo con la Sección 1049 de la Ley de Autorización para la Defensa Nacional para el Año Fiscal 2002 (Ley Pública 107–107). Aproximadamente 900 acres del antiguo VNTR, que consiste de la LIA, es manejado como un área silvestre donde no se permite el acceso del público siguiendo la Ley Pública 106–398 y la Ley Pública 107–107.

DOI desarrolló un Plan Abarcador de Conservación (CPP, por sus siglas en inglés) en 2007 para el Refugio Nacional de Vida Silvestre de Vieques que describe un marco conceptual para el manejo del refugio (DOI, 2007). La restauración ambiental del antiguo VNTR se basa en los riesgos potenciales para la salud humana y el ambiente identificados a través del proceso de la Ley de Respuesta, Compensación y Responsabilidad Ambiental (CERCLA,

por sus siglas en inglés), junto con los requerimientos aplicables o relevantes y apropiados (ARARs, por sus siglas en inglés), teniendo en consideración el uso futuro de los terrenos que se identificó en el CCP.

Oeste de Vieques (Antiguo NASD)

El 30 de abril de 2001, los 8,114 acres del antiguo NASD en el lado oeste de Vieques fueron repartidos y se transfirieron al DOI, al Municipio de Vieques (MOV, por sus siglas en inglés) y al Fideicomiso de Conservación de Puerto Rico (PRCT, por sus siglas en inglés), de acuerdo con la Ley Pública 106- 398 (Figura ES-3). La propiedad del DOI (aproximadamente 3.158 acres) está manejada por USFWS como parte del Refugio Nacional de Vida Silvestre de Vieques. Al igual que el antiguo VNTR, la restauración ambiental del antiguo NASD se basa en los riesgos potenciales para la salud humana y el ambiente identificados a través del proceso de CERCLA, junto con los ARARs, y teniendo en consideración el uso futuro previsto para los terrenos.

Objetivo y Descripción General del Uso

El objetivo de utilizar AGC en el antiguo VNTR y en el antiguo NASD es ayudar en la caracterización de la naturaleza y la extensión de los componentes de municiones (MC, por sus siglas en inglés), si éstos están presentes bajo la superficie del suelo. Sin el uso de AGC, se lleva a cabo una cartografía geofísica digital convencional (DGM, por sus siglas en inglés) para identificar las ubicaciones de objetos de metal debajo de la superficie; se debe investigar un subconjunto de estas localidades para cumplir con los objetivos de la RI. El muestreo de suelos para MC sólo se realiza cuando se recuperan artículos de municiones, y requiere un número mínimo de muestras de suelo (especificado en el SAP). Por lo tanto la selección preferencial de los lugares donde es más probable que se encuentre un artículo de municiones (o "un punto específico de interés" [TOI, por sus siglas en inglés]) permitirá que cumplan con los objetivos de la RI utilizando un menor número de investigaciones intrusivas. Esto permitirá un itinerario acelerado, mientras que se cumplen con los objetivos del proyecto.

Bajo este QAPP se utilizará un enfoque modificado de AGC para disminuir el número total de anomalías que requieren investigación intrusiva durante las investigaciones MC al permitir la selección preferencial de TOI. Debido a que estas investigaciones no son parte de las acciones de remoción, estos datos no están siendo utilizados para clasificar los "objetos meta" como TOI o como no TOI, éstos sólo se utilizan para crear una lista de prioridades preliminar que será utilizada para seleccionar preferentemente los artículos que probablemente son municiones enterradas.

Los elementos de AGC que se requieren para avanzar de la lista de prioridades preliminar a la lista de prioridades final (y clasificar los objetos meta como "TOI" o "no-TOI ") incluyen llevar a cabo análisis de calibración de las excavaciones, excavaciones de verificación umbral, y excavaciones de validación. Estos elementos no son requeridos para cumplir con los objetivos de esta investigación, por lo tanto no se realizarán. Nótese que todas las actividades que dan lugar a la generación de la lista de prioridades preliminar se llevarán a cabo de tal manera que los datos apoyarán la AGC completa una vez que se lleven a cabo los elementos restantes.

Se utilizará un sensor de inducción electromagnética avanzada (EMI, por sus siglas en inglés) conocido como el TEMTADS 2x2 (TEMTADS) para 1) realizar estudios dinámicos para detectar artículos metálicos debajo de la superficie del suelo que son TOI potenciales, y 2) realizar investigaciones con pautas estáticas para apoyar la clasificación geofísica de cada objeto meta seleccionado, de manera que los objetos puedan clasificarse en una lista de prioridades, donde los objetos de mayor prioridad son los que se consideran TOI con más probabilidad. Además, los estudios de detección geofísicos dinámicos se pueden realizar con un Geonics, Ltd. EM61-MK2 (EM61) seguido de una investigación con claves estática por medio de tecnología EMI avanzada.

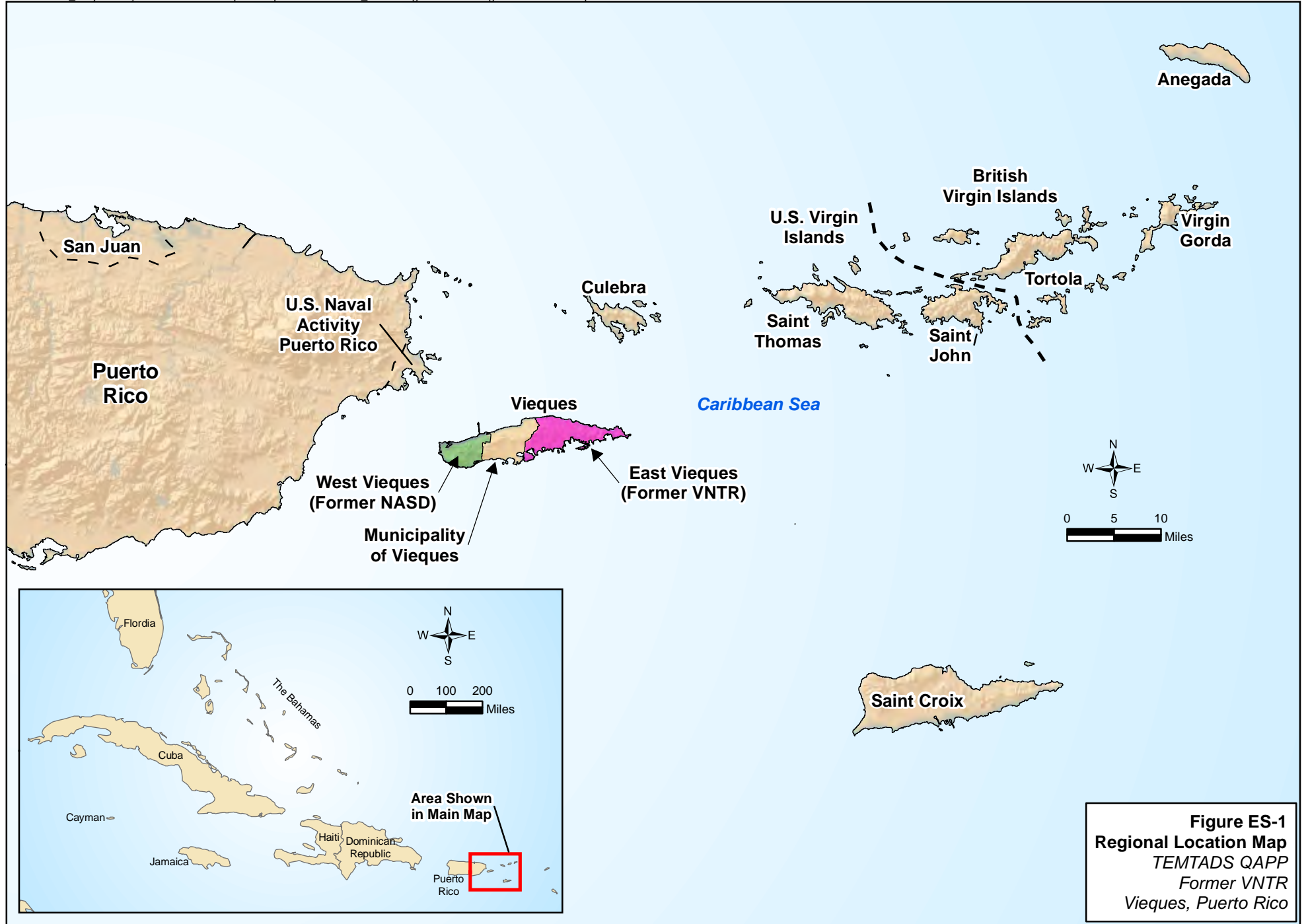
Las actividades generales que CH2M llevará a cabo para lograr el objetivo antes mencionado incluyen:

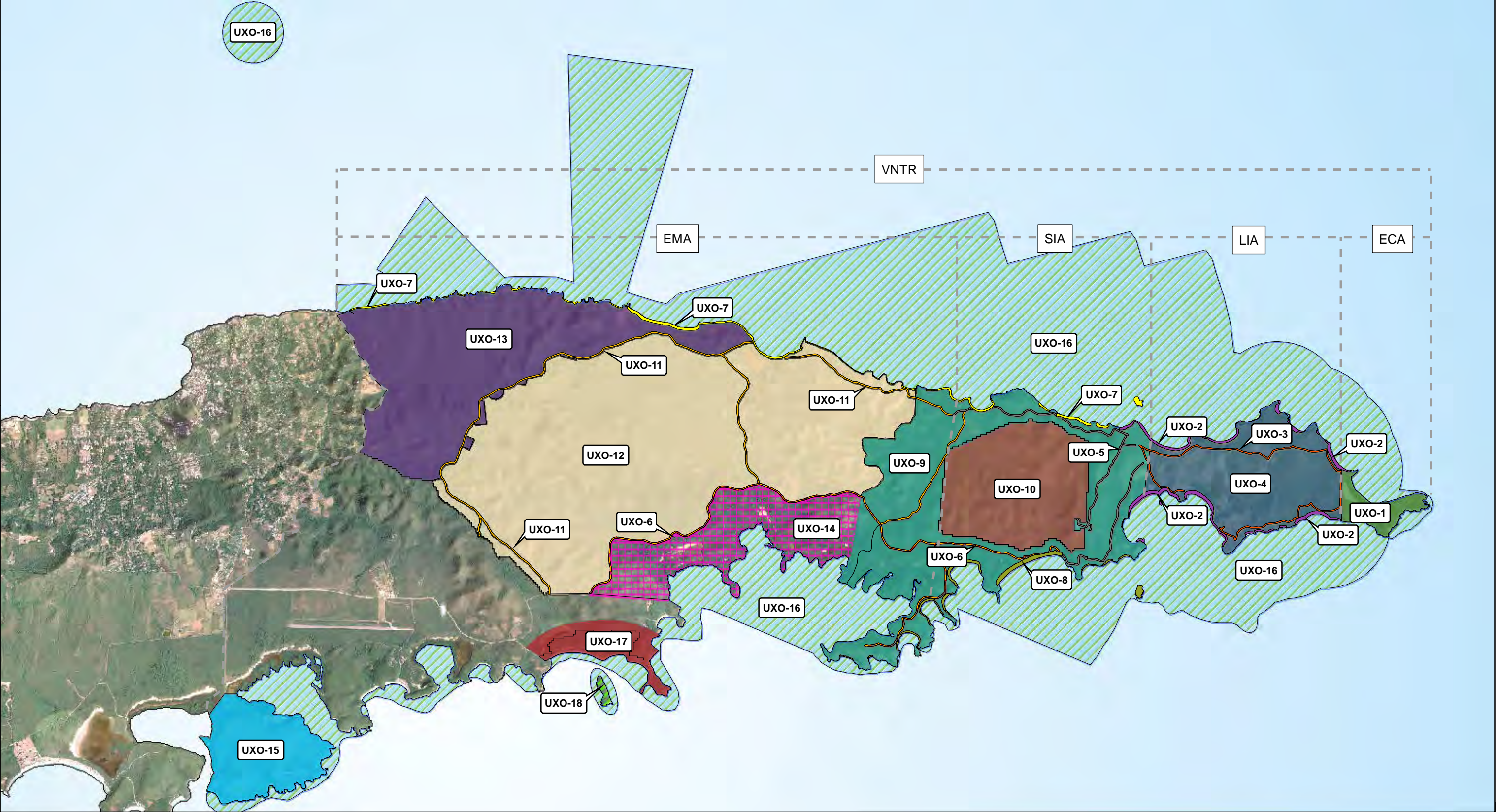
1. Llevar a cabo estudios geofísicos dinámicos en las áreas accesibles al sistema de posicionamiento global (GPS, por sus siglas en inglés) utilizando los TEMTADS o el EM61, para detectar objetos metálicos debajo de la superficie del suelo que pueden ser TOI (por ejemplo, municiones).

2. Realizar Detección Avanzada en el conjunto de datos dinámicos de TEMTADS para identificar fuentes de anomalías con potencial de ser TOI (Detección Avanzada no se puede realizar en los datos obtenidos con el EM61). A diferencia del análisis de Respuesta de Amplitud convencional, donde todas las respuestas anómalas por encima de un umbral establecido como objetivo son investigadas, la Detección Avanzada es un proceso que utiliza el conjunto de datos abundantes disponible de los sensores EMI avanzados para seleccionar los objetos meta¹ en base a las características de la fuente de la anomalía (tamaño y espesor de la pared). Este método reduce significativamente el esfuerzo requerido para investigar las anomalías causadas por fuentes que son demasiado pequeñas o que tienen paredes demasiado delgadas para ser un TOI viable.
3. Desarrollar una interrogación en clave de los artículos meta identificados en el estudio dinámico para crear una lista de prioridades preliminar. El uso de interrogación en clave implica el uso de los TEMTADs en modo estático y el análisis de los datos estáticos utilizando un programa de computadora de clasificación estática diseñado para ese fin. Este programa deriva parámetros extrínsecos (localización y orientación) y parámetros intrínsecos (relacionados con la forma del objeto meta) y compara los parámetros intrínsecos con la biblioteca de datos específicos del sitio de municiones candidatas. Sobre la base de esta comparación, se deriva una lista de prioridades para excavar, en la cual aquellas que se asemejen más a municiones se excavan primero.

¹ Note que el término “objeto meta” puede referirse a una localización de un pico de anomalía (de detecciones de “respuesta de amplitud” convencionales) o una localidad “fuente de anomalías” derivada de la metodología de detección avanzada del objeto meta.

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- Legend**
- Munitions Response Sites**
- UXO 1 - ECA
 - UXO 2 - LIA Beaches
 - UXO 3 - LIA Roads
 - UXO 4 - LIA Interior
 - UXO 5 - SIA Restricted Roads
 - UXO 6 - EMA/SIA Public Roads
 - UXO 7 - EMA/SIA North Beaches
 - UXO 8 - SIA South Beaches
 - UXO 9 - SIA Exterior
 - UXO 10 - SIA Interior
 - UXO 11 - EMA Public Roads
 - UXO 12 - EMA Interior
 - UXO 13 - EMA West
 - UXO 14 - EMA South
 - UXO 15 - Puerto Ferro
 - UXO 16 - Underwater Areas
 - UXO 17 - Other Sites (PAOC EE)
 - UXO 18 - Cayo de la Chiva

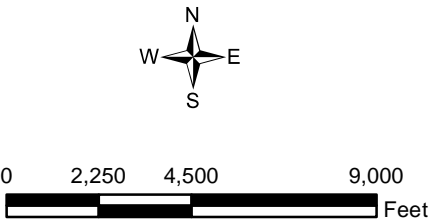
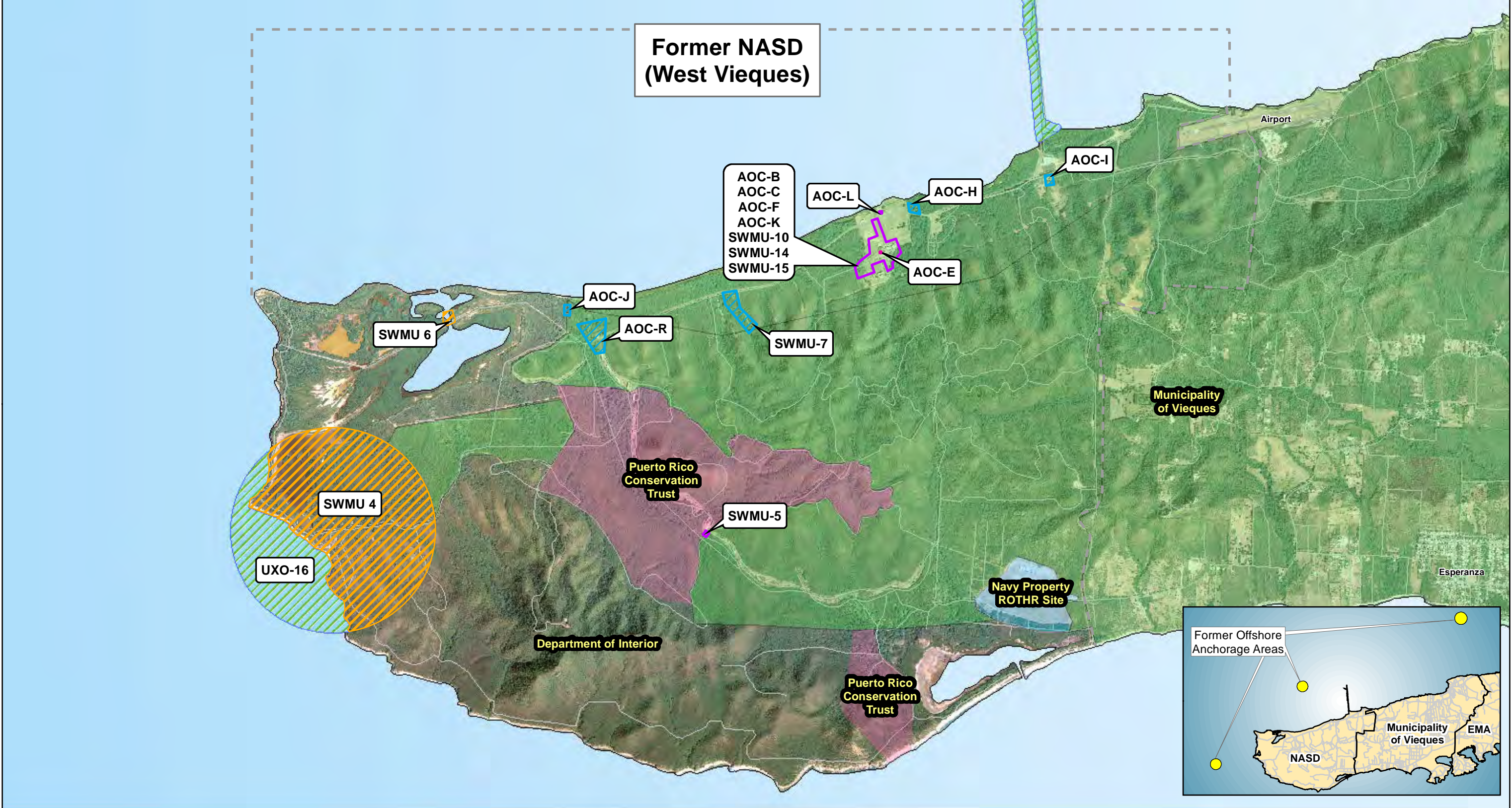


Figure ES-2
East Vieques Munitions Response Sites
TEM TADS QAPP
Former VNTR
Vieques, Puerto Rico



Legend

- | | | |
|--------------------------------------|-------------------------------|--------------------------------|
| Remedial Action | Vieques Land Ownership | Munitions Response Site |
| No Further Action Record of Decision | Department of Interior | UXO 16 -Underwater Areas |
| No Further Action Decision Document | Municipality of Vieques | Vieques Features |
| Feasibility Study Addendum | Navy Property - ROTH Site | Road |
| | PR Conservation Trust | |

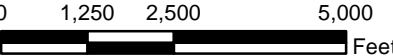


Figure ES-3
West Vieques Sites
TEM TADS QAPP
Former VNTR
Vieques, Puerto Rico

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- 4 West Vieques Sites

Acronyms and Abbreviations

A/E/C	Architecture, Engineering, Construction
AGC	Advanced Geophysical Classification
AGCMRRI	Advanced Geophysical Classification Munitions Response Remedial Investigation
AHA	Activity Hazard Analysis
AM	Activity Manager
APP	Accident Prevention Plan
AQM	Activity Quality Manager
ARAR	applicable or relevant and appropriate requirement
BG	background
CA	corrective action
CADD	Computer-Aided Drafting and Design
CAP	Corrective Action Plan
CAR	Corrective Action Request
CCP	Comprehensive Conservative Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-term Environmental Action-Navy
cm	centimeter
CPR	cardiopulmonary resuscitation
CQMC	Construction Quality Management for Contractors
CSDGM	Content Standard for Digital Geospatial Metadata
CSM	Conceptual Site Model
DDESB	Department of Defense Explosives Safety Board
DFW	definable feature of work
DGM	digital geophysical mapping
DoD	Department of Defense
DOI	Department of the Interior
DQO	data quality objective
ECA	Eastern Conservation Area
EM	Engineering Manual
EM61	Geonics Electromagnetic sensor EM61-MK2
EMA	Eastern Maneuver Area
EMI	electromagnetic induction
EOD	explosive ordnance disposal
EPA	Environmental Protection Agency
ESRI	Environmental System Research Institute
ESS	Explosives Safety Submission
ESTCP	Environmental Security Technology Certification Program
EZ	exclusion zone
FCR	Field Change Request
FGDC	Federal Geographic Data Committee
FP	follow-up phase
ft	foot/feet

FTL	Field Team Leader
FTP	file transfer protocol
GCMR	Geophysical Classification for Munitions Response
GIS	geographic information system
GPS	global positioning system
H&S	Health and Safety
IAW	in accordance with
ID	identifier
IMU	inertial measurement unit
IP	Initial Phase
ISO	industry standard object
IVS	instrument verification strip
LIA	Live Impact Area
m	meter
MC	munitions constituent
MD	munitions debris
MDAS	material documented as safe
MEC	munitions and explosives of concern
mm	millimeter
MOV	Municipality of Vieques
MPC	measurement performance criteria
MPPEH	material potentially presenting an explosive hazard
MQO	measurement quality objective
MR	Munitions Response
MRP	Munitions Response Program
MRS	Munitions Response Site
MRSIMS	MRS Information Management System
mv	millivolt
mV/A	millivolt/ampere
NAD	North American Datum
NASD	Naval Ammunition Support Detachment
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NCR	Non-Conformance Report
NPL	National Priorities List
NSSDA	National Standard for Spatial Data Accuracy
OSHA	Occupational Safety and Health Administration
PDF	portable document format
PE	Professional Engineer
PLS	Professional Land Surveyor
PM	Project Manager
PP	Preparatory Phase
PPE	personal protective equipment
PRCT	Puerto Rico Conservation Trust
PRDNER	Puerto Rico Department of Natural and Environmental Resources
PREQB	Puerto Rico Environmental Quality Board

QA	quality assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	quality control
QCS	Quality Control Specialist
RCA	Root Cause Analysis
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RPM	Remedial Project Manager
RTK	Real-time Kinematic
SAP	Sampling and Analysis Plan
SDSFIE	Spatial Data Standards for Facilities, Infrastructure, and Environment
SIA	Surface Impact Area
SNR	signal to noise ratio
SOP	Standard Operating Procedure
SSHP	Site-Specific Health and Safety Plan
SUXOS	Senior Unexploded Ordnance Supervisor
SWMU	Solid Waste Management Unit
TBD	to be determined
TEMA	towed electromagnetic induction array
TEMTADS	Time-domain Electro-Magnetic Multi-sensor Towed Array Detection System
TOI	target of interest
TP	Technical Paper
U.S.	United States
UFP-SAP	Uniform Federal Policy Sampling and Analysis Plan
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
UXO	unexploded ordnance
UXOQCS	Unexploded Ordnance Quality Control Specialist
UXOSO	Unexploded Ordnance Safety Officer
VNTR	Vieques Naval Training Range

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QAPP Worksheet #1 & 2: Title and Approval Page

1. Project Identifying Information

Site Name/Project Name Atlantic Fleet Weapons Training Area/TEMTADS
Site Location/Number Former Vieques Naval Training Range, Vieques, Puerto Rico
Client Department of the Navy (Navy),
Naval Facilities Engineering Command (NAVFAC), Atlantic
Contractor CH2M
Contract Number N62470-11-D-8012, Contract Task Order 019

2. Department of Defense (DoD) Organization

DoD Project Manager (PM) (name/title/signature/date)

Daniel Hood/Kevin Cloe, Remedial Project Manager (RPM)
NAVFAC Atlantic

CLOE,KEVIN.R.1229533
947
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DN: c=US, o=U.S. Government, ou=DoD, ou=PKI,
email=SA, cn=CLOE,KEVIN.R.1229533947
Date: 2016.11.29 15:36:44 -05'00'

DoD Quality Manager (name/title/signature/date)

Mike Green, MR Quality Assurance Officer (QAO)
NAVFAC Atlantic

3. Contractor

Contractor PM (name/title/signature/date)

Bill Hannah, PM
CH2M

Bill Hannah
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Date: 2016.12.05 10:21:51
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Contractor Quality Assurance Manager (name/title/signature/date)

George DeMetropolis, Quality Manager
CH2M

George DeMetropolis
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Date: 2016.12.05 07:24:38 -08'00'

4. Federal Regulatory Agency (name/title/signature/date)

Julio Vazquez, RPM
United States EPA Region 2

JULIO
VAZQUEZ
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ou=USEPA, ou=Staff, cn=JULIO
VAZQUEZ, dnQualifier=0000013169
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5. Commonwealth Regulatory Agencies (name/title/signature/date)

Juan Baba Peebles, RPM
Puerto Rico Environmental Quality Board (PREQB)

Juan J Babá
Peebles
Digitally signed by Juan J Babá Peebles
DN: cn=Juan J Babá Peebles, ou=PREQB,
Government, ou=PREQB,
email=juanbabapeebles@pr.gov, c=US
Date: 2016.12.02 09:32:57 -04'00'

Craig Lilyestrom, RPM
Puerto Rico Department of Natural and Environmental
Resources (PRDNER)

Craig Lilyestrom

QAPP Worksheet #1 & 2: Title and Approval Page

1. Project Identifying Information

Site Name/Project Name Atlantic Fleet Weapons Training Area/TEMTADS
Site Location/Number Former Vieques Naval Training Range, Vieques, Puerto Rico
Client Department of the Navy (Navy),
Naval Facilities Engineering Command (NAVFAC), Atlantic
Contractor CH2M
Contract Number N62470-11-D-8012, Contract Task Order 019

2. Department of Defense (DoD) Organization

DoD Project Manager (PM) (name/title/signature/date)

Daniel Hood/Kevin Cloe, Remedial Project Manager (RPM)
NAVFAC Atlantic

DoD Quality Manager (name/title/signature/date)

Mike Green, MR Quality Assurance Officer (QAO)
NAVFAC Atlantic

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ID.1042977876

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DN: c=US, o=U.S. Government, ou=DoD, ou=PKI,
ou=USN, cn=GREEN.MICHAEL.DAVID.1042977876
Date: 2016.11.29 08:52:07 -05'00'

3. Contractor

Contractor PM (name/title/signature/date)

Bill Hannah, PM
CH2M

Contractor Quality Assurance Manager (name/title/signature/date)

George DeMetropolis, Quality Manager
CH2M

4. Federal Regulatory Agency (name/title/signature/date)

Julio Vazquez, RPM
United States EPA Region 2

5. Commonwealth Regulatory Agencies (name/title/signature/date)

Juan Baba Peebles, RPM
Puerto Rico Environmental Quality Board (PREQB)

Craig Lilyestrom, RPM
Puerto Rico Department of Natural and Environmental
Resources (PRDNER)

QAPP Worksheet #1 & 2: Title and Approval Page (continued)

6. Other Stakeholders

Susan Silander, RPM
USFWS

SUSAN SILANDER

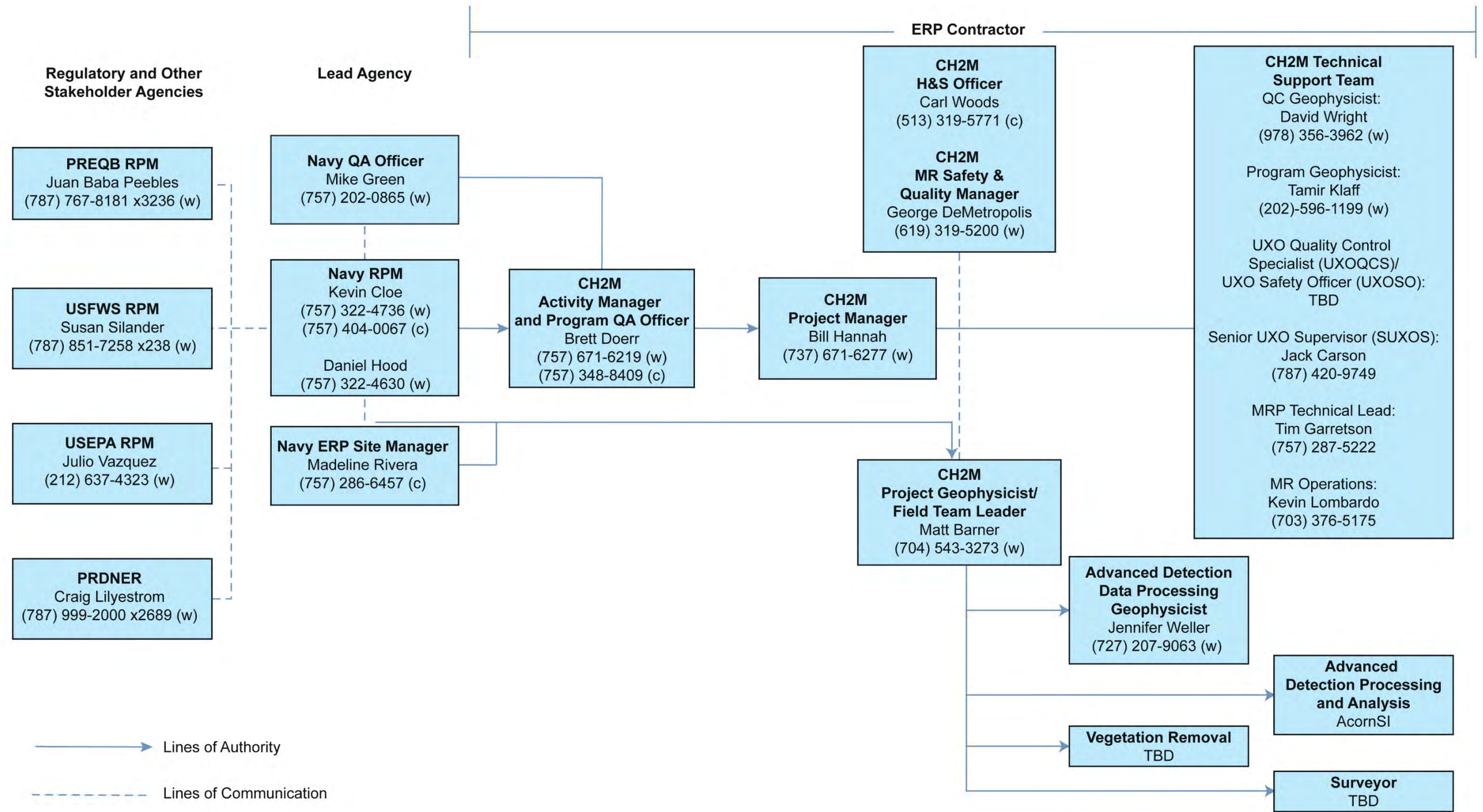
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7. List plans and reports from previous investigations relevant to this project

Title	Author/Date
See Reference section	

QAPP Worksheet #3 & 5: Project Organization and QAPP Distribution

FIGURE 3-1
Geophysics Survey and Explosive Operations Organizational Structure



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QAPP Worksheet #4, 7 & 8: Personnel Qualifications and Sign-off Sheet

TABLE 4-1
Geophysical Survey Organization

Name	Project Title	Experience/Specialized Training/Licenses/Certifications	Role	Signature/Date ¹
Brett Doerr	Activity Manager	OSHA 40-hour, Current on 8-hour Refresher, First Aid and CPR Certified More than 20 years of project management LEED GA credentials Professional Geologist (PG)	Serves as the primary contact for CH2M. Develops the project scope, schedule, and budget. Provides day-to-day management of the CH2M team and schedule and lead meetings and review conferences. Responsible for the safe, efficient, and quality execution of the project and for ensuring the subcontractors deliver their work safely, to specifications and to quality standards. Authority includes making process, procedure, and managerial decisions regarding specific project issues; negotiating with subcontractors; approving subcontractor deliverable performance and invoices; developing and implementing the Project Management Plan, Site-Specific Health and Safety Plan (SSHP), and QAPP.	
George DeMetropolis	Health and Safety (H&S)/Quality Control (QC) Manager	Cardiopulmonary resuscitation (CPR) and First Aid Training OSHA 8-hour 29 CFR 1910.120(e)(4) Refresher OSHA 8-hour CFR 1910.120(3)(4) Site Supervisor OSHA 40-hour CFR 1910.120(e)(3) American Society for Quality Certified Quality Auditor & Certified Manager of Quality/Organizational Excellence Former Military Master Explosive Ordnance Disposal (EOD) Technician United States Army Corps of Engineers (USACE) UXO Resume Database: 0421 USACE Construction Quality Management for Contractors (CQMC)	Responsible for overall safe execution of all work and for compliance with all USACE safety requirements. Ensures that procedures described in this Geophysical Classification for Munitions Response (GCMR)-QAPP are safe and that all safety requirements are implemented in the field. Conducts safety audits. Provides overall program quality management and implementation on the project. Responsibility for identifying quality problems and will initiate, recommend, and/or provide corrective measures to those problems. Verifies the implementation of corrective measures and conducts senior-level reviews of contract deliverables. Monitors activities at the work sites and coordinates activities with the PM, Site Manager, and Unexploded Ordnance (UXO) QC Specialist (UXOQCS). Approves all plans and all changes or deviations from established procedures or techniques.	
Jack Carson	Senior Unexploded Ordnance Supervisor (SUXOS)	Qualifications Established by DoD Explosives Safety Board (DDESB)Technical Paper (TP) 18	Primary point of contact for communications during operational efforts for issues relating to field actions and daily schedules. Serves as the Site Manager during fieldwork activities. Responsible for management and leadership of the project during its operational cycles and will be onsite to provide direct oversight of field activities. Maintains a field log of daily activities, records of anomaly excavations, and disposal documentation (if applicable). Submits daily progress Contractor Production Report to CH2M PM. Essential for performing tasks within an exclusion zone (EZ) while munitions and MEC activities are being conducted, pursuant to Engineering Manual (EM) 385-1-97 (USACE, 2008).	
TBD	Unexploded Ordnance Safety Officer (UXOSO)/ UXOQCS	Qualifications Established by DDESB TP 18	Implements the approved H&S program in compliance with applicable DoD policy and federal, state, and local H&S statutes, regulations, and codes. Schedules the daily safety briefings. Analyzes operational risks, explosive hazards, and safety requirements. Establishes and ensures compliance with all site-specific explosives operations safety requirements. Enforces personnel limits and safety EZs for explosives-related operations. Conducts, documenting, and reporting the results of safety inspections to ensure compliance with all applicable explosives safety policies, standards, regulations, and codes. Ensures all protective works and equipment used within the EZ are operated in compliance with applicable DoD policy, and federal, state, and local H&S statutes, regulations, and codes. Is responsible for oversight of placement and documentation of QC seed items by CH2M UXO personnel and professional land surveying subcontractor in accordance with applicable standard operating procedures (SOPs). Provides required documentation on QC seed placement to the QC Geophysicist on a daily basis during the seeding event. Conducts and documents QC audits for compliance with established procedures and identifies, documents, reports, and ensures completion of all corrective actions (CAs) to ensure operations comply with requirements. Essential, pursuant to EM 385-1-97 (USACE, 2008), for performing tasks within an EZ while MEC activities are being conducted.	

¹ Signatures indicate personnel have read and agree to implement this QAPP as written.

QAPP Worksheet #4, 7 & 8: Personnel Qualifications and Sign-off Sheet (continued)

TABLE 4-1
Geophysical Survey Organization

Name	Project Title	Experience/Specialized Training/Licenses/Certifications	Role	Signature/Date ¹
Tamir Klaff	Program Geophysicist	More than 20 years of project management and technical experience designing, implementing and managing geophysical operations and 18 years focused on MR projects (hundreds of sites). Significant training and experience with advanced EMI data collection and processing. Experienced in management and design of environmental investigations and remedial actions (Resource Conservation and Recovery Act [RCRA]/CERCLA) and UXO/chemical warfare materiel clearance and disposal programs Professional Registered Geophysicist, 2001, California No. GP 1036 Professional Geologist since 1998, Current registration: Virginia 2801001878 UX Analyze courses Occupational Safety and Health Administration (OSHA) 40-hour, Current on 8-hour Refresher, OSHA Supervisor	Overall responsibility for design, implementation, and management of geophysical investigations required for the work. Ensures proper oversight of field geophysical operations. Approves use of geophysical equipment, reviews and approves field data. Provides CH2M PM with status updates on geophysical data collection, processing, and QC. Informs CH2M PM of deviations from QAPP, if necessary. Communicates relevant project and schedule updates to geophysical field team. Reviews and approves geophysical project deliverables and documents (including root cause analysis [RCA] and CAs, if necessary).	
Jennifer Weller	Data Processing Geophysicist	Over 10 years in geophysical consulting experience Conducted geophysical operations and data processing on MR sites within the United States (U.S.) and U.S. territories, with extensive experience in geophysical data processing and analysis including advanced EMI surveys, has also provided QC of DGM data. OSHA 40-hour, Current on 8-hour Refresher, First Aid and CPR Certified through The American Heart Association	Overall responsibility for processing DGM and advanced EMI data and classifying anomalies Responsible for QC of data received from the field team Communicates QC issues to Project Geophysicist and Field Team Leader (FTL) Ensures geophysical data meet the measurement quality objectives (MQOs) Ensures data packages are complete prior to transmitting to the QC Geophysicist Assists with preparation and compilation of geophysical project deliverables and documents (including RCAs and CAs, if necessary).	
Matt Barner	Project Geophysicist/FTL	Over 14 years in geophysical consulting experience Conducted geophysical operations on MR sites within the U.S. and abroad, with extensive experience in design and execution of field surveys, planning, QC of DGM data, and oversight of field operations, including advanced EMI surveys. Professional Geologist, VA and NC OSHA 40-hour, Current on 8-hour Refresher	Kicks off field investigation and is responsible for continued oversight of geophysical field operations. Conducts training of field geophysical personnel as needed. Ensures data are transferred daily to Project Geophysicist for review and analysis. Ensures field documentation is completed in accordance with (IAW) the QAPP prior to upload for data processing. Assists with preparation and compilation of geophysical project deliverables and documents (including RCAs and CAs, if necessary).	
David Wright	QC Geophysicist	More than 25 years of experience in practical geophysics, performing and managing a diverse array of geophysical investigations using airborne, terrestrial, and marine based systems. Significant involvement in developing and demonstrating innovative technologies for MR detection/classification including playing lead role in developing airborne and marine UXO detection arrays and led the development of a dual mode magnetometer/EMI handheld device. Experienced in performing as project geophysicist for a number of recent Advanced Classification demonstrations. Active in supporting the Environmental Security Technology Certification Program (ESTCP) Program Office in development of formalized Quality Management for Advanced Classification.	Is responsible for reviewing QC seed placement process and documentation from UXOSO/UXOQCS for compliance with applicable SOPs. Is responsible for verifying necessary supporting data (e.g. those provided by professional land surveying subcontractor) have been received and are complete. Reviews geophysical data packages for compliance with the QAPP. Ensures geophysical data processing is being performed IAW with QAPP. Performs QC of geophysical data in timely manner and communicates QC concerns or problems to Project Geophysicist. Ensures QC documentation is completed IAW the QAPP.	

TABLE 4-2
Explosive Operations Organization

Name	Project Title	Experience/Specialized Training/Licenses/Certifications	Role	Signature/Date
In addition to personnel listed in Table 4-1:				
TBD	UXO Team	Qualifications Established by DDESB TP 18	Execute fieldwork activities as directed by the SUXOS and UXOSO	

¹ Signatures indicate personnel have read and agree to implement this QAPP as written.

QAPP Worksheet #6: Communication Pathways and Procedures

Communication Driver	Initiator (Name, Title/Role, and Contact Info)	Recipient (Name, Title/Role, and Contact Info)	Procedure (Timing, Pathway, Documentation)
Regulatory agency interface	Kevin Cloe/Daniel Hood Vieques RPMs 757-322-4736/ kevin.chloe@navy.mil 757-322-4630/ daniel.r.hood@navy.mil	Juan Baba Peebles PREQB PM 787-767-8181 x3236 juanbaba@jca.pr.gov Susan Silander USFWS 787-851-7258 x238 susan_silander@fws.gov Julio Vazquez EPA RPM 212-637-4323 Vazquez.julio@epa.gov Craig Lilyestrom PRDNER RPM 787-999-2000 x2689 Craig.Lilyestrom@drna.pr.gov	Navy RPM provides project updates to regulatory stakeholders via email, telephone, or meetings, as necessary.
Vieques	Kevin Cloe/Daniel Hood Vieques RPMs 757-322-4736/ kevin.chloe@navy.mil 757-322-4630/ daniel.r.hood@navy.mil OR Brett Doerr CH2M Activity Manager (AM) 757-671-6219 brett.doerr@ch2m.com	Madeline Rivera Vieques Site Manager 757-348-2689 llamasmad@gmail.com	Activities requiring facility input or coordination
Stop work due to safety issues	Jack Carson CH2M SUXOS/UXOSO 787-420-9749 jack.carson@ch2m.com	Brett Doerr CH2M AM 757-671-6219 brett.doerr@ch2m.com	As soon as possible following discovery, SUXOS/UXOSO informs CH2M AM by phone of critical safety issues and generates follow-up Stop Work Memorandum. CH2M AM then informs Navy RPMs.

QAPP Worksheet #6: Communication Pathways and Procedures (continued)

Communication Driver	Initiator (Name, Title/Role, and Contact Info)	Recipient (Name, Title/Role, and Contact Info)	Procedure (Timing, Pathway, Documentation)
Minor QAPP changes during project execution (field CA)	George DeMetropolis CH2M QC Manager 619-272-7239 george.demetropolis@ch2m.com OR Brett Doerr CH2M AM 757-671-6219 brett.doerr@ch2m.com	Kevin Cloe/Daniel Hood Vieques RPMs 757-322-4736/ kevin.chloe@navy.mil 757-322-4630/ daniel.r.hood@navy.mil	CH2M prepares a Field Change Request (FCR) (Form 6-9 in Attachment A) and, as applicable, a Corrective Action Request (CAR) (Form 6-10 in Attachment A) and Corrective Action Plan (CAP) (Form 6-11 in Attachment A). CH2M AM or PM provides to Navy RPM for review and approval and informs regulators upon approval.
Major QAPP changes during project execution	Brett Doerr CH2M AM 757-671-6219 brett.doerr@ch2m.com	Kevin Cloe/Daniel Hood Vieques RPMs 757-322-4736/ kevin.chloe@navy.mil 757-322-4630/ daniel.r.hood@navy.mil	CH2M AM or PM submits FCR form to Navy RPM for approval. Following approval, Navy RPM informs regulatory stakeholders via email.
Field progress reports	Bill Hannah CH2M PM 757-671-6277 Bill.hannah@ch2m.com	Kevin Cloe/Daniel Hood Vieques RPMs 757-322-4736/ kevin.chloe@navy.mil 757-322-4630/ daniel.r.hood@navy.mil	At end of each week of fieldwork, CH2M PM provides daily QC reports to Navy RPM via email.
Geophysical QC variances	David Wright CH2M QC Geophysicist 978-356-3962 david.wright@ch2m.com	Kevin Cloe/Daniel Hood Vieques RPMs 757-322-4736/ kevin.chloe@navy.mil 757-322-4630/ daniel.r.hood@navy.mil	CH2M team prepares a FCR (Form 6-9 in Attachment A) and, as applicable, a CAR (Form 6-10 in Attachment A) and CAP (Form 6-11 in Attachment A). CH2M PM or AM provides to Navy RPM for review and approval.
Data verification issues, e.g., incomplete records	Tamir Klaff CH2M Program Geophysicist 202-596-1199 tamir.klaff@ch2m.com	Kevin Cloe/Daniel Hood Vieques RPMs 757-322-4736/ kevin.chloe@navy.mil 757-322-4630/ daniel.r.hood@navy.mil	CH2M team prepares a FCR (Form 6-9 in Attachment A) and conducts an RCA of the verification issue. A CAR (Form 6-10 in Attachment A) and CAP (Form 6-11 in Attachment A) will be prepared, as applicable. CH2M PM or AM provides to Navy RPM for review and approval.
Data review CA	David Wright CH2M QC Geophysicist 978-356-3962 david.wright@ch2m.com	Kevin Cloe Vieques RPM 757-322-4736 kevin.chloe@navy.mil	CH2M team prepares a FCR (Form 6-9 in Attachment A) and conducts an RCA of the data issue. A CAR (Form 6-10 in Attachment A) and CAP (Form 6-11 in Attachment A) will be prepared, as applicable. CH2M PM or AM provides to Navy RPM for review and approval.

QAPP Worksheet #9: Project Planning Session Summary

Date of Planning Session: December 2, 2015
Location: New York
Purpose: Discuss use of TEMTADS
Participants: See December 2015 Vieques Technical Subcommittee meeting minutes

Name	Organization	Title/Role	Email/Phone

Notes/Comments

The path forward is to integrate TEMTADS into the RI of roads and beaches to identify the conservative soil sampling locations; potential use for subsurface MEC removal where conditions are favorable (low-moderate anomaly densities, small munitions or flares are not the primary TOI); and consider participation in developing the requirements for the proposed DoD Advanced Geophysical Classification Accreditation Program.

Date of Planning Session: April 12, 2016
Location: New York
Purpose: Discuss use of TEMTADS
Participants: See April 2016 Vieques Technical Subcommittee meeting minutes

Name	Organization	Title/Role	Email/Phone

Notes/Comments

Mr. Doerr provided an overview on the TEMTADS QAPP recently provided to the regulators for review. The QAPP is to be used in association with RIs (i.e., to help select locations for subsurface sampling associated with munitions). The key point is that the level of quality assurance (QA)/QC in a TEMTADS QAPP used for investigation does not need to be the same as that necessary for a TEMTADS QAPP that was to be used for a removal or remedial action where decisions would be made whether to leave something in the ground or not. The intent for investigations is just to identify areas for sampling and to avoid having to dig up a lot of scrap before a munitions item is found for sampling. The approach will be especially helpful along the roads, where there is a lot of scrap. Tom Hall asked how TEMTADS performs with 20-mm versus frag; Mr. Hood responded that the system does not distinguish 20-mm from frag or scrap with a high level of confidence.

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QAPP Worksheet #10: Conceptual Site Model

This QAPP provides supplemental guidance for AGC activities performed in support of RIs that are being conducted at the former VNTR and NASD under investigation-specific SAPs. The Conceptual Site Model (CSM) is provided in the Addendum 4, Master Sampling and Analysis Plan, UXOs 3, 5, 6, and 11 Remedial Investigation. (CH2M, 2016).

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QAPP Worksheet #11: Project Quality Objectives

Step 1: State the Problem.

Site-specific problem statement: Previous findings at the former NASD (Solid Waste Management Unit [SWMU] 4) and former VNTR indicate the potential for munitions items to be present in the subsurface. These items may present an unacceptable explosive hazard to site workers, visitors, trespassers, and recreational users. Additionally these items present potential for release of MC. AGC use for MR RI activities will be conducted in accordance with this QAPP, the Master Sampling and Analysis Plan, East Vieques Terrestrial UXO Sites (CH2M, 2013), and Addendum 4, Master Sampling and Analysis Plan, UXOs 3, 5, 6, and 11 Remedial Investigation (CH2M, 2016). The activities being performed in accordance to this document are limited to preferentially selecting targeted locations for intrusive investigation and subsequent MC sampling. As this is not a removal/remedial action, AGC with the intent of identifying anomaly locations that do not require removal is not a project objective.

Under this QAPP, EM61 or TEMTADS sensors will be used to:

1. Detect metal potentially associated with munitions and other debris and use the locations of these detections to create a target list.
2. Using AGC, cued (and potentially dynamic) TEMTADS measurements will be used to rank these targets with respect to their likelihood of being a buried munition.

It is expected that AGC will reduce the number of intrusive investigations required to find buried munitions for MC sampling.

Step 2: Identify the goals of the data collection.

Identify the principal question: Are there metal objects in the subsurface of the area of interest and, if so can they be ranked in a prioritized list so that munitions items can be preferentially identified for intrusive investigation and MC sampling?

Identify alternative outcomes: Where discrete buried targets can be detected and identified, these targets will be ranked from most likely to be a TOI to least likely to be a TOI.

State how the data will be used in solving the problem: Geophysical data collected in dynamic mode will be used to initially detect and document the locations of geophysical anomalies in the subsurface. These data will be collected using either a TEMTADS or an EM61. Responses indicating the presence of potential TOI will be used to generate a list of targets.

Traditional detection surveys performed with the EM61 use the geophysical response amplitude to indicate the presence of potential TOI. Peak anomaly responses above a predetermined signal to noise ratio (SNR) threshold are used to indicate the locations of potential TOI. Because the signal amplitude is very sensitive to distance of the targets from the sensor (i.e. depth), the detection threshold must be set low enough to capture the smallest potential TOI at depth. In so doing, many smaller metal objects closer to the surface are also detected. Response amplitude threshold detection may also be used with data collected with the TEMTADS sensor. However, the TEMTADS sensor provides a much richer data set, allowing for Advanced Detection to be used to reject many non-TOI. Because it uses a much richer data set, Advanced Detection also has the advantage of an increased depth of detection of TOI in support of munitions removal and investigations. Advanced Detection works by identifying anomaly sources (rather than just the anomaly), and features related to these sources (primarily size and wall thickness) are estimated from the data and used to reject those sources that are too small to be viable TOI. Advanced Detection may be used for the TEMTADS data to identify TOI as well as identify targets that will be further evaluated in the cued survey. Dynamic EM61 data do not support Advanced Detection; therefore, for

QAPP Worksheet #11: Project Quality Objectives (continued)

areas where the EM61 is used for the dynamic survey, all identified geophysical anomaly locations must be intrusively investigated or further evaluated using cued TEMTADS measurements.

Geophysical data recorded with the TEMTADS in cued (static) mode will be used to derive a prioritized target list. This list will not be the basis for a dig/no-dig classification decision, it is only prioritized to minimize the number of intrusive investigations required to reach the project sampling requirements (i.e. intrusive investigation will only be performed on the prioritized list until enough munitions items are recovered to support the MC sampling requirements of the project).

Step 3: Identify information inputs.

Data and information needed to satisfy the goals of the investigation are listed below.

- Elements of the current CSM and findings of previous studies described in Worksheet #10, including:
 - Site history and uses
 - Range boundaries
 - Types and quantities of munitions items known or suspected to be present
 - Expected distribution of MEC (area, expected maximum depth, depth distribution, anomaly source density, etc.)
 - Topography, geology, vegetation
 - Land use considerations
 - Reasonably anticipated future uses
 - Current and future receptors
 - Exposure pathways
 - Access restrictions or other obstacles to investigation
 - Endangered species, sensitive habitats, and historic or cultural resources that could be affected by traffic or other disturbances occurring during the investigation
 - Locations of underground utilities
 - Assumptions, data gaps, and sources of uncertainty
- Site Preparation Information
 - Munitions Response Site (MRS) boundary
 - Surveyed locations of cultural features not shown on existing maps
 - Temporary benchmark details
 - Surveyed locations of grid corners
 - Surface sweep results
 - Surveyed validation and QC seed locations

QAPP Worksheet #11: Project Quality Objectives (continued)

- Detection survey results, including:
 - Dynamic survey footprint
 - System QC test results
 - Instrument verification strip (IVS) results
 - Geo-referenced geophysical responses
 - Data analysis results, including
 - Anomaly locations (X, Y) for follow-up cued survey
 - Unique anomaly identification numbers
 - Z-component amplitude and advanced detection features for each anomaly
 - Potential background locations (X, Y) for use during cued survey
 - Anomaly density maps
 - Advanced Detection and Target Selection Memorandum (for TEMTADS data only)
- AGC cued survey results, including:
 - System QC results
 - IVS results
 - Background measurements and usability assessment
 - Unique anomaly identification numbers and locations
 - Site-specific munitions classification library
 - Cued survey measurements
 - Preliminary Prioritized Dig List based on fit coherence with library matches

Step 4: Define the boundaries of the project.

Target population: The target population includes the munitions items listed in Worksheet #10 that were previously found at the former VNTR and NASD. Exceptions for this investigation include small arms ammunition and flares, fuzes, and pieces of munitions items (for example, tail fins and mortar bases). Small arms ammunition are not MEC and will not be considered TOI. Flares are typically constructed of thin-walled material, deform easy in the subsurface, and therefore mimic debris (i.e., clutter) in the subsurface. Fuzes and pieces of munitions items also mimic clutter in the subsurface. Geophysical Classification uses the shape and wall-thickness to classify targets as TOI or non-TOI. Thus items that mimic clutter cannot be effectively differentiated from clutter, and geophysical classification is not appropriate for classifying these items

Characteristics of interest: The physical characteristics of interest are the size, axial symmetry, aspect ratio, composition and wall-thickness that will be used by the AGC process to derive a prioritized list by comparison of these derived target features to a site-specific library of munitions features. The site-specific library will contain signatures for munitions that are anticipated to be present at the site, based upon the CSM. If there is a munition type in the CSM that does not have an existing library entry, measurements of an inert sample will be made to derive a signature to be added to the library.

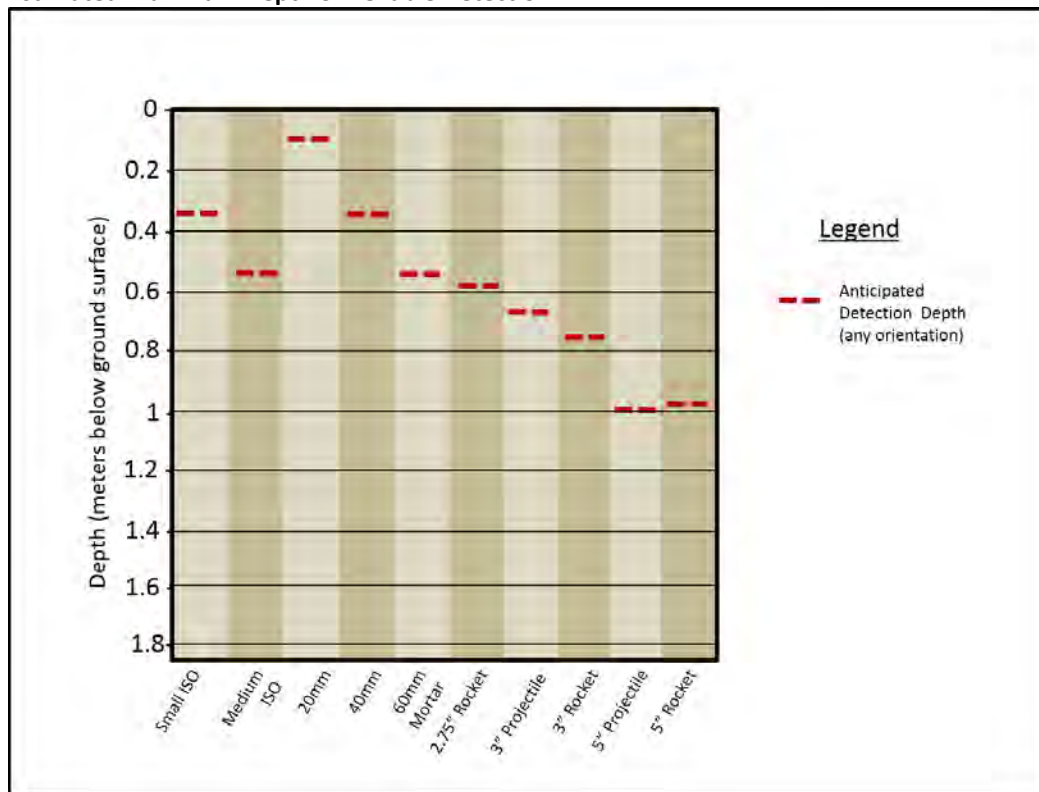
QAPP Worksheet #11: Project Quality Objectives (continued)

Spatial and temporal boundaries: The horizontal boundaries are specified in the SAP.

The vertical boundary will vary for each munition type depending upon the munition-specific maximum depth of reliable detection. The maximum depth of reliable detection is a function of the SNR. For a given sensor, the expected signal for each munition of interest can be calculated in advance, but the noise levels are site-specific. Thus the vertical boundary will ultimately be determined during the investigation. However, for planning purposes the noise levels and the resulting maximum depth of reliable detection can be estimated. **Figure 11-1** presents the estimated maximum depth of reliable detection for a selection of munitions from the CSM. These examples are appropriate for use to estimate maximum reliable depths of detection for similar sized ordnance.

FIGURE 11-1

Estimated Maximum Depth of Reliable Detection



For a given task the spatial boundaries, including the munitions specific vertical boundaries will be re-specified in an addendum to this document.

Step 5: Develop the Project Data Collection and Analysis Approach.

The TEMTADS or EM61 will be used to collect data in a dynamic mode. For the EM61, target locations will be selected using conventional amplitude response criteria (any location where an anomaly peak exceeds the predetermined threshold is selected as a target for further investigation). This same method, or Advanced Detection will be used with the dynamic TEMTADS data to identify the locations of potential subsurface TOI. Advanced Detection is only appropriate for RTK-GPS enabled surveys. Target locations of potential subsurface TOI will be further evaluated in a TEMTADS cued survey (static mode). Anomaly density maps will be derived using a 10 m² grid cell size and 1 m resolution. For each 1 m grid node, the number of anomalies in the surrounding 10 m² area will be counted and multiplied by 404.7 to provide the anomaly density in anomalies per acre.

QAPP Worksheet #11: Project Quality Objectives (continued)

Static TEMTADS data will be analyzed using Geosoft Oasis Montaj's UX Analyze module, which contains physics-based models to estimate the physical attributes of the sources of anomalies, and classifier models to estimate the likelihood that the sources of the anomalies are TOI. The final product will be a prioritized dig list (ranked target list) that classifies each target location through a transparent, quantitative approach.

Detection Phase

This phase is designed to detect potential TOI which meet the measurement criteria within the survey area.

Parameters of interest: For EM61 detection surveys, the parameters of interest are the response amplitude and the background noise levels (measured in units of millivolts [mV]). The detection threshold will be established during the dynamic survey of the study area but will correspond to 5x the nominal sensor noise levels. The basis for the threshold ultimately established will be presented in the dynamic survey IVS report. The parameters of interest for TEMTADS surveys using conventional amplitude response detection are the same as those described for EM61 surveys, with the exception that the units are measured on millivolts/ampere (mV/A).

For TEMTADS surveys using Advanced Detection, the parameters of interest include:

- The initial dipole coherence metric (a unit-less number representing the correlation between the observed data [1 meter (m) x 1 m data chips extracted every 0.1 m grid node] and a modelled dipole at each position). This metric is used to identify dipole response regions in the survey area.
- The derived 'size' and 'decay' values for each (buried metal) source identified using three invocations of a dipole fit routine (positing 1, 2, and 3 sources respectively) used to investigate all dipole response regions.

Type of inference: Measurements meeting the established criteria noted above will be considered to be potential TOI and selected as targets for further evaluation using cued static TEMTADS measurements and geophysical classification.

Decision rules:

1. If an anomaly response amplitude during the dynamic EM61 surveys is greater than or equal to the established detection threshold, the anomaly will be selected and placed on the Amplitude Response Anomaly List. The established detection threshold will be a function of the SNR, currently projected to be 5x the nominal sensor noise level.
2. For TEMTADS dynamic surveys, if the dipole fit coherence is above the established detection threshold, data associated with the elevated fit coherence will be selected for three invocations of the n-dipole fit routine (positing 1, 2, and 3 sources respectively). The established detection threshold will be a function of the site-specific noise levels.
3. For TEMTADS dynamic surveys, all sources identified using the n-dipole fit routines as being large enough and having a long decay (indicative of being thick-walled) will be identified as potential TOI and will be placed on the Advanced Detection Target List. The size and decay cutoff thresholds will be determined by the smallest and thinnest-walled TOI.

Cued Phase

Parameters of interest: For the cued survey, the parameters of interest are the cued measurement SNR, inversion fit coherence, inversion outputs of intrinsic (β_1 , β_2 , β_3) and extrinsic (x, y, and z) source features, and the fit correlation of the intrinsic features to a library of TOI items. These parameters will be derived from cued measurements recorded for each target location selected from the dynamic survey results.

QAPP Worksheet #11: Project Quality Objectives (continued)

Type of inference: The targets will be ranked using the fit correlation of the intrinsic features to a site-specific library of TOI.

Decision rules:

1. If a portion of the investigation area is determined to have an anomaly density greater than 3,000 anomalies per acre (too high for cued analysis of individual anomaly locations), then an alternative approach will be developed and proposed to the project team.
2. Targets at the top of the prioritized target list will be preferentially selected for intrusive investigation/MC sampling.

Step 6: Specify Project-Specific Measurement Performance Criteria.

Project-specific measurement performance criteria (MPC) are presented in Worksheet #12. Project-specific MPCs are the criteria that collected data must meet to satisfy the Data Quality Objectives (DQOs). Failure to achieve the MPCs may have an impact on the end uses of the data, which will be discussed in the Data Usability Assessment Report.

Step 7: Survey Design and Project Work Flow.

The MPCs established during Step 6 of the DQO process (documented in worksheet #12) were used to develop the sample design described in Worksheet #17.

QAPP Worksheet #12: Measurement (Project) Performance Criteria

Definable Feature of Work (DFW)	Data Quality Indicator	Specification	Activity Used to Assess Performance
Site Preparation (Surface QC Seeding)	Representativeness/Completeness	Surface blind QC seeds placed at site. Blind QC seeds will consist of small Schedule 80 industry standard objects (ISOs) and will be located throughout the survey boundary defined in the MQOs. The small ISOs will be used for surface seeding because their shape and dimensions are consistent with the smallest munitions expected at the site, and they are easily obtained in sufficient quantities. Seeds will be placed at an approximate rate of 16 seeds per acre IAW SOP MR-AC-20-01.	Comparison of actual placement data (quantity and survey coordinates) to specifications in QAPP
Surface Sweep	Completeness	Not more than five pieces of exposed or partially exposed metallic objects exceeding 2 inches (5 centimeters) in any dimension, remain within a 0.2-acre area.	Visual inspection by UXOQCS of approximately 10% of each grid
Surface Sweep	Completeness	100% of accessible portions of survey area is covered.	Confirm all surface QC seeds have been returned to UXOQCS
Site Preparation (Subsurface QC Seeding)	Representativeness/Completeness	Subsurface blind QC seeds placed at site. Blind QC seeds will consist of small Schedule 80 ISOs and, if available, inert munitions of the types anticipated at the site, and will be located throughout the survey area. The small ISOs will be used as subsurface QC seeds because they can be picked above sensor noise levels, the signatures are in the UX-Analyze library, are similar in size to challenging TOI (37 millimeter [mm] Projectile), and are easily obtained in sufficient quantities. They are also logistically feasible to place at varying burial depths up to their maximum detection depth in the subsurface. A ratio of approximately 50% of each type of seed will be placed, assuming a sufficient number of inert items are available for use as blind seeds (the total number of seeds is not restricted by the availability of inert munitions, but the ratio of inert munitions to ISOs may be limited). QC seeds will be placed in the subsurface IAW SOP MR-AC-21-01 to ensure that at least one seed will be placed for every team day of dynamic and cued interrogation surveys anticipated. The seeds will be placed at depths up to but not exceeding the maximum detectable depth determined for each of the types of QC items, with a distribution of items from just below the surface to that depth in the horizontal (most difficult to detect) position. The maximum expected detection depths, burial depths, and justification for these depths will be addressed in the QC Seeding Technical Memorandum after initial site-specific data are gathered and sensor-specific noise levels can be quantified.	Comparison of actual placement data (quantity and recorded depths and orientations) to specifications in QAPP

QAPP Worksheet #12: Measurement (Project) Performance Criteria (continued)

Definable Feature of Work (DFW)	Data Quality Indicator	Specification	Activity Used to Assess Performance
Dynamic Detection Survey (EM61)	Completeness	100% of accessible portions of survey area is sampled.	Confirm in-line measurement spacing IAW Worksheet #22 MQOs
Dynamic Detection Survey (EM61)	Sensitivity	The detection threshold will be 5x the nominal sensor noise levels. The sensor-specific noise levels will be determined during initial data gathering efforts. <i>(Note: specific thresholds for sites within VNTR to be presented in an addendum to this QAPP)</i>	Confirm initial and ongoing IVS surveys and QC (blind) seed detection IAW Worksheet #22 MQOs Analysis of background variability across the site
Dynamic Detection Survey (EM61)	Accuracy/Completeness	100% of validation and QC seeds must be detected.	Review of validation and QC seed detection results per survey unit
Dynamic Detection Survey (EM61)	Precision/Bias	RTK-GPS enabled surveys: targets located within 0.5 meters (1.7 feet [ft]) of ground truth Fiducially positioned surveys: targets located within 1.0 meters (3.3 ft) of ground truth	Confirm initial and ongoing IVS surveys and QC (blind) seed detection IAW Worksheet #22 MQOs
Dynamic Detection Survey (EM61)	Completeness	DGM data and target lists delivered.	Inspection/acceptance of data deliverables
Dynamic Detection Survey (TEMTADS)	Completeness	100% of accessible portions of survey area is sampled.	Confirm in-line measurement spacing IAW Worksheet #22 MQOs
Dynamic Detection Survey (TEMTADS)	Sensitivity	The detection threshold will be 5x the nominal sensor noise levels. The sensor-specific noise levels will be determined during initial data gathering efforts. <i>(Note: specific thresholds for tasks /subsites within VNTR to be presented in an addendum to this QAPP)</i>	Confirm initial and ongoing IVS surveys and QC (blind) seed detection IAW Worksheet #22 MQOs Analysis of background variability across the site
Dynamic Detection Survey (TEMTADS)	Accuracy/Completeness	100% of validation and QC seeds must be detected.	Review of validation and QC seed detection results per survey unit

QAPP Worksheet #12: Measurement (Project) Performance Criteria (continued)

Definable Feature of Work (DFW)	Data Quality Indicator	Specification	Activity Used to Assess Performance
Dynamic Detection Survey (TEMTADS)	Precision/Bias	Derived positions of targets are within 0.4 meters (1.3 ft) of ground truth	Confirm initial and ongoing IVS surveys and QC (blind) seed detection IAW Worksheet #22 MQOs
Dynamic Detection Survey (TEMTADS)	Completeness	Geophysical data archive and target lists delivered	Inspection/acceptance of data deliverables
Classification Survey	Completeness/Comparability	Library will include signatures for munitions known or suspected to be present at the site (IAW Worksheet #10) for which a reliable, inert item exists. Exceptions include small arms, fuzes, and flares.	Inspection of site-specific library used for classification
Classification survey	Representativeness/Accuracy	Background data will be collected at least once every two hours of cued survey data collection. Background locations will be selected such that background data will be representative of the various subsurface conditions expected to be encountered within each survey unit at the site.	Data verification/data validation
Classification Survey	Completeness	All detected anomalies included in the prioritized list.	Inspection/acceptance of data deliverables
Classification Survey	Accuracy/Comparability	All TOI are correctly identified for intrusive investigation.	Inspection of classification results for all known TOI (QC and validation seed performance, IVS, and recovered training dig TOI) IAW Worksheet #22 MQOs
Classification Survey	Completeness/Comparability	Complete Geosoft database.	Data verification Data validation
Classification Survey	Completeness	In addition to Geosoft database, inversion results delivered as portable document format (PDF) files illustrating (at a minimum) the three estimated primary axis polarizabilities, the polarizabilities of the best library match, quality indicators for measured data, quality indicators for inversion results, and quantitative classification metrics.	Inspection/acceptance of data deliverables

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QAPP Worksheet #13: Secondary Data Uses and Limitations

(UFP-QAPP Manual Section 2.7)
 (EPA Guidance QA/G-5, Chapter 3)

Data Type	Source	Data Uses Relative to Current Project	Factors Affecting the Reliability of Data and Limitations on Data Use
Topographic	United States Geological Survey (USGS)	Areas where EM-61 or TEMTADS instrumentation may be used	None
Range history, munitions use and disposal, historical geophysical data; geophysical data collected under other work planning documents	Various historical documents, including aerial photographs	List of possible munition items used and general proximities of use; existing geophysical data; locations of geophysical anomalies identified via DGM conducted under other work planning documents	Used to help identify locations for EM-61 and TEMTADS use; newly collected geophysical data will supersede historical geophysical data

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QAPP Worksheet #14 & 16: Project Tasks & Schedule

Below is a list of tasks generally to be conducted during implementation of AGC. For any particular project, if the task list varies from that shown below, it will be provided in the project-specific SAP or an addendum to this QAPP. The schedule of activities will be dependent on the particular project, which is defined by the annual Site Management Plan.

- Site preparation including surface sweep
- Seeding and IVS construction
- Detection survey
- Data processing, verification, validation and usability evaluation (Detection Phase)
- Advanced detection dipole analysis
- Cued survey
- Data processing, verification, validation, classification and usability evaluation (Cued Phase)
- Report

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QAPP Worksheet #17: Survey Design and Project Work Flow

DFW	Associated Activities (see Attachment B for referenced SOPs)	Supporting Document(s)
1. Pre-Mobilization Activities	Prepare blind seed firewall plan Prepare draft validation plan Set up Geographic Information System (GIS) Set up MRS Information Management System (MRSIMS)	See Worksheet #10
2. Conduct Site Preparation	Mobilize staff Mobilize equipment Kickoff/Safety Meeting Perform boundary survey with anomaly avoidance If necessary, emplace grid corner stakes in accordance with established VNTR site-wide grid system (100 ft x 100 ft) (30 m x 30 m) with anomaly avoidance Perform surface sweep (MR-AC-22-01 expect no contact with MPPEH; EOD response required for MPPEH during surface sweep); prepare Surface Sweep Technical Memorandum	GCMR-QAPP Accident Prevention Plan (APP) SSHP Activity Hazard Analyses (AHAs)
3. Conduct Validation Seeding, QC Seeding, and Construct IVS	Place surface QC seeds (CH2M) (MR-AC-20-01) Place subsurface QC seeds (CH2M) and quality assurance (QA) seeds (third party) with UXO/anomaly avoidance and survey locations (MR-AC-21-01) Establish IVS Prepare QC Seeding Technical Memorandum	GCMR-QAPP APP SSHP AHAs
4. Assemble and Verify Correct Operation of Geophysical Sensor to be Used for Detection Survey	Assemble TEMTADS or EM61 for dynamic survey and verify operation (MR-AC-01-01 or MR-SS-02-01) Provide assembly checklist	GCMR-QAPP APP SSHP AHAs
5. Dynamic Detection Survey	Perform initial dynamic IVS survey and prepare Initial IVS Technical Memorandum (MR-AC-02-01) Perform dynamic detection survey (MR-AC-03-01 or MR-SS-01-01)	GCMR-QAPP APP SSHP AHAs
6. Process Dynamic Survey Data and Document Target Locations	Process dynamic data (MR-AC-04-01 and MR-SS-02-01) Prepare Target Selection Memorandum for dynamic survey	GCMR-QAPP APP SSHP AHAs
7. Assemble Advanced Geophysical Sensor and Test Sensor at IVS	Assemble TEMTADS for cued survey and verify operation (MR-AC-01-01) Perform initial cued IVS survey and prepare IVS Technical Memorandum (MR-AC-05-01) Prepare assembly checklist	GCMR-QAPP APP SSHP AHAs
8. Classification (Cued Interrogation) Survey	Reacquire and flag anomaly and potential background locations, verify background locations (MR-AC-06-01) Perform cued survey with TEMTADS (MR-AC-06-01)	GCMR-QAPP APP SSHP AHAs

QAPP Worksheet #17: Survey Design and Project Work Flow (continued)

DFW	Associated Activities (see Attachment B for referenced SOPs)	Supporting Document(s)
9. Validate Advanced Sensor Data	Perform QC on daily cued interrogation survey (MR-AC-06-01) Verify that MQOs are met with daily data set Prepare QC documentation	GCMR-QAPP APP SSH AHAs
10. Conduct Cued Data Processing	Process cued survey data (MR-AC-07-01)	GCMR-QAPP APP SSH AHAs
11. Classify Anomalies and Make Dig/No-Dig Decisions	Classify anomaly sources and generate TOI/non-TOI classification spreadsheet (MR-AC-07-01) Prepare Preliminary Prioritized Dig List	GCMR-QAPP APP SSH AHAs

QAPP Worksheet #17: Survey Design and Project Work Flow (continued)

1. Pre-Mobilization Activities

1.1 Prepare Blind Seed Firewall Plan

A Blind Seed Firewall Plan is provided in **Attachment C** detailing CH2M's approach to limiting distribution of the information on the types, depths, and locations of QC seeds placed at the site.

1.2 Prepare Draft Validation Plan

A Draft Validation Plan, designed to provide assurance that there are no TOI classified as non-TOI, is provided in **Attachment D**. The plan details CH2M's approach to validation, including validation of appropriate target selection methods, thresholds for library matching, cluster analysis and feature analysis. The document will be made 'Final' after completion of the final TOI and non-TOI databases have been delivered to the Navy and prior to performance of validation digs.

1.3 Geographic Information System

A project GIS has been established and all relevant geospatial-related data and information will be contained in the GIS.

1.3.1 Location Surveying and Mapping

CH2M uses the Federal Geographic Data Committee (FGDC) Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (NSSDA), and Part 4: Standards for Architecture, Engineering, Construction (A/E/C) and Facility Management, which are found at www.fgdc.gov/standards/publications for any point positioning such as GPS.

Navigational data will be correlated with horizontal control based upon a local Third Order Class 1 (1:10,000) or better, monument or survey marker. Survey data will be provided in North American Datum 1983 (NAD83), Universal Transverse Mercator (UTM) 20N, meters. If necessary, a Commonwealth of Puerto Rico registered Professional Land Surveyor (PLS) will document compliance with all accuracy specifications.

1.3.2 Geographic Information System Incorporation

Environmental Systems Research Institute, Inc. (ESRI)–compliant formats (shape files, coverages, or geodatabases) will be used to present GIS data during the project, with supporting tabular data provided in Microsoft Excel format, Microsoft Access format, or both, as needed.

In addition, each GIS data set will be accompanied by metadata conforming to FGDC's Content Standard for Digital Geospatial Metadata (CSDGM) and be provided in a geodatabase that is compliant with the Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE). The horizontal accuracy of GIS data created by CH2M will be tested in accordance with the NSSDA and the results will be recorded in the metadata.

1.3.3 Mapping

The location, identification, coordinates, and elevations of all control points that are recovered and/or established at the site will be plotted on one or more site maps. Each control point will be identified on the map by its name and number and the final adjusted coordinates.

Each map will include a legend showing the standard symbols used for the mapping, a north arrow, and a title block.

1.3.4 Digital Data

Location information will be collected as part of the geophysical surveys to approximate the position of each anomaly in the GIS.

QAPP Worksheet #17: Survey Design and Project Work Flow (continued)

1.3.5 Computer Files and Digital Data Sets

All final document files, including reports, figures, and tables, will be submitted in electronic format. These files will be compatible with Microsoft Office 97 or later formats and in PDF on CD-ROM.

All geospatial data will conform to the Computer-Aided Drafting and Design (CADD)/GIS Technology Center Spatial Data Standards for Facilities Infrastructure and Environment and will be provided in metric units.

1.4 Munitions Response Program Enterprise

CH2M will utilize its Munitions Response Program (MRP) Enterprise system for recording field notes, data file names, site conditions, and other relevant information during field operations. Information is entered into a forms-based operating system using tablet personal computers in the field for use by data processing and QC personnel. MRP Enterprise is described in greater detail in Worksheet #29.

2. Conduct Site Preparation

A mobilization period will include mobilizing staff and securing and deploying equipment. Mobilization activities will include general activities and a kickoff and safety meeting.

2.1 Mobilization

2.1.1 General Activities

The general activities to be performed as part of mobilization include the following:

- Identify/procure, package, ship, and inventory project equipment
- Coordinate communications with logistical support
- Finalize operating schedules
- Test and inspect equipment (See Worksheet #22 for details)
- Assemble and transport the work force
- Conduct site-specific training on the QAPP and MEC procedures and hazards
- Verify that all forms and project documentation are in order and CH2M team members understand their responsibilities with regard to completion of project reporting requirements

2.1.2 Kickoff/Safety Meeting

During mobilization, a kickoff and site safety meeting will be conducted. This meeting will include a review of this QAPP and review and acknowledgment of the APP by all site personnel. Additional meetings will occur as needed and as new personnel, visitors, and/or subcontractors arrive at the site.

2.2 Use of Established Site-wide Operational Grid

The field team will use the established site-wide 30 m by 30 m operational grid system for lane control and to separate the survey into manageable units. All survey files and field notes will reference the appropriate grids, as applicable.

2.3 Surface Sweep/Preparation of Surface Sweep Technical Memorandum

UXO Technicians will perform a surface sweep in accordance with SOP MR-AC-22-01 (see **Attachment B**) and the Explosives Safety Submission (ESS). Non-munitions related metallic items having a dimension of at least 2 inches (5 centimeters) in any dimension will be removed from the surface of the survey area.

QAPP Worksheet #17: Survey Design and Project Work Flow (continued)

All material potentially presenting an explosive hazard (MPPEH) on the surface will be dealt with by UXO personnel during the surface preparation.

A technical memorandum will be prepared upon completion of the surface sweep. The memorandum will present the findings of the surface sweep, including the nature and quantity of objects identified on the surface within the operational grids and the surface sweep QC results. The memorandum will also summarize the procedures undertaken during disposition of objects found on the surface. This memorandum will ultimately be included in the project-specific report.

3. Conduct Validation Seeding, Quality Control Seeding, and Construct Instrument Verification Strip

3.1 Surface Quality Control Seeding

The UXOQCS will place QC seeds on the surface across the survey area in accordance with SOP MR-AC-20-01 (see **Attachment B**) prior to the performance of surface sweeps. The seeds will consist of small schedule 80 ISOs. Approximately 16 QC seeds will be placed on the surface per acre IAW SOP MR-AC-20-01.

3.2 Subsurface Quality Control Seeding

The UXOQCS will place QC seeds in the subsurface across the survey area in accordance with SOP MR-AC-21-01 (see **Attachment B**). The QC seeds will be comprised of both inert munitions items, if available, and small, schedule 80 ISOs. The small ISOs have been selected as they are an item that will be picked out of the data as a target of interest (the small ISO signature is in the UX-Analyze library), are similar in size to the most challenging TOI at the site that are detectable and classifiable (37 mm projectile [or other based on site-specific TOIs]), and they are easily obtained. They are also logistically feasible to place in significant quantities and at burial depths up to their maximum detection depth in the subsurface. A ratio of approximately 50 percent of each type of seed will be placed, assuming a sufficient number of inert items are available for use as blind seeds (while the number of inert munitions seeds may be limited by availability, the number of ISOs and thus total number of seeds will have no such limitation). QC seeds will be placed in the subsurface to ensure that at least one seed will be encountered for every team day of dynamic and cued interrogation surveys.

The seeds will be placed at depths up to but not exceeding the maximum detectable depth determined for each of the types of QC items, with a distribution of items from just below the surface to that maximum depth. The orientation of the seeds will also be varied.

The information on the seeds will be documented, provided to the Navy prior to starting the dynamic detection surveys, and ultimately included in the project-specific report.

3.3 Validation Seeding

A third party (e.g., Navy) will develop the approach to validation seeding and physically place the seeds within the survey area. The types of validation seeds, quantity, depths, and locations will remain unknown to CH2M. It is expected that the validation seeding would be performed in a manner consistent with the subsurface QC seeding; information regarding sensor noise levels, site-specific background responses will be provided to the third party for use in development of the validation seeding plan.

QAPP Worksheet #17: Survey Design and Project Work Flow (continued)

3.4 Establish Instrument Verification Strip

An IVS will be established within close proximity to the survey area for EM61 and TEMTADS testing and validation prior to use for both the dynamic and cued surveys. The IVS will be established as described in SOP MR-AC-05-01 (see **Attachment B**). Part of the IVS establishment process includes the collection of a background (i.e., pre-seeded) dynamic survey with the EM61 or TEMTADS at the intended IVS location in order to first assess the location's suitability for construction of the IVS. Seed items placed within the IVS will be located at least 1 m (3.3 ft) from geophysical anomaly locations (if any) identified in the pre-seeded survey. In particular, the IVS will be used for twice daily testing during the dynamic and cued interrogation surveys as part of the QC program. Twice daily testing, where specified in Worksheet #22 Tables 22-1 and 22-2, will include a minimum of testing at the start and end of each day data are collected (barring unforeseen events that would preclude collection of the end of day IVS test such as severe weather). Additional tests may be conducted at the IVS as needed during the course of each survey.

4. Assemble and Verify Correct Operation of Geophysical Sensor to be Used for Detection Survey

The TEMTADS system will be assembled as described in SOP MR-AC-01-01 and the EM61 system will be assembled as described in SOP MR-SS-01-01 (see **Attachment B**).

5. Dynamic Detection Survey

5.1 17.5.1 Initial Dynamic Survey IVS

In order to test the system selected for the dynamic survey (EM61 or TEMTADS) and verify that it is set-up and functioning properly, an initial dynamic IVS survey will be performed as described in SOP MR-SS-01-01 for EM61 surveys (see **Attachment B**). The IVS will include two schedule 80 small ISOs buried horizontally, perpendicular to the transect at approximately 15 centimeters (cm) (6 inches) and 10 cm (4 inches), respectively.

After performance of the initial dynamic IVS using the TEMTADS or EM61, the Initial IVS Technical Memorandum will be prepared detailing the IVS setup, surveys, and results, including documentation of compliance with the dynamic IVS MQOs provided in Worksheet #22. The Initial IVS Technical Memorandum will ultimately be provided to the internal project team and ultimately included in the project-specific report.

5.2 Perform Dynamic Detection Survey

After performance of the initial dynamic IVS, dynamic EM61 or TEMTADS data will be collected in order to identify the locations of metal in the subsurface for cued interrogation. The dynamic detection survey will be performed as described in SOP MR-AC-03-01 for TEMTADS surveys and SOP MR-SS-01-01 for EM61 surveys (see **Attachment B**). The existing site-wide operational 30 m by 30 m grid system will be used by the field team to set up survey lanes appropriate to meet the lane spacing MQOs provided in Worksheet #22. The intended lane spacing for the dynamic surveys is 0.5 m (1.6 ft) for the TEMTADS and 0.75 m (2.5 ft) for the EM61. If surveying will be conducted along transects instead of by grid, a QAPP addendum will be submitted.

QAPP Worksheet #17: Survey Design and Project Work Flow (continued)

6. Process Dynamic Survey Data and Document Anomaly Locations

Dynamic TEMTADS data will be processed as described in SOP MR-AC-04-01 and EM61 data will be processed as described in SOP MR-SS-02-01 (see **Attachment B**). Anomaly sources identified for cued interrogation will be selected from the data using Advanced Detection for TEMTADS data or from the time gate at 660 microseconds (Channel 3) for dynamic surveys utilizing the EM61. Anomaly sources identified as potential TOI will be placed on the target list. In addition, potential background locations will be identified from either the monostatic, z component dynamic response data for TEMTADS data or from Channel 3 for EM61 data for use during the cued survey phase.

The Dynamic Data Analysis and Target Selection Technical Memorandum will include a summary of the dynamic data processing and target selection approach, culminating in the target list. This memorandum will also identify potential background locations for use during the cued survey, a summary of survey area coverage and relative anomaly density, and stipulate whether the MQOs have been met thus far.

If a portion of the survey area is determined to have an anomaly density too high for reliable identification of discrete targets, then an alternative approach for these areas will be documented in the Dynamic Data Analysis and Target Selection Technical Memorandum. The Memorandum will ultimately be included in the project-specific report.

7. Assemble Advanced Geophysical Sensor and Test Sensor at IVS

7.1 Assemble TEMTADS for Cued Survey and Verify Operation

Because the cued surveys require a slightly different setup than the dynamic surveys, the TEMTADS systems will be modified per SOP MR-AC-01-01 (see **Attachment B**).

7.2 Perform Initial Cued IVS Survey and Prepare IVS Technical Memorandum Addendum

After setup of the TEMTADS systems for cued surveys, the IVS previously established for the dynamic surveys will be used to perform an initial cued IVS at each IVS measurement location in accordance with SOP MR-AC-05-01 (see **Attachment B**) to confirm that the sensor is set up and functioning properly.

After performance of the initial cued IVS, an IVS Technical Memorandum Addendum will be prepared detailing the cued IVS surveys and results, including documentation of compliance with the cued IVS MQOs provided in Worksheet #22. This memorandum will be provided to the internal project team and ultimately included in the project-specific report.

8. Classification (Cued Interrogation) Survey

8.1 Reacquire and Flag Anomaly Locations

Anomalies identified for cued interrogation will be reacquired and marked using vinyl-stem surveyor flags. Reacquisition will be performed using RTK GPS or conventional survey methods (total station) in accordance with SOP MR-AC-06-01. The anomaly location identifier will be written in indelible marker on a surveyor flag placed at the anomaly location, with an appropriate, consistent safety factor applied to the positions in order to avoid the flag being placed directly on top of a potential munition item. As an alternative, CH2M may elect to perform real-time navigation using RTK GPS to the target locations with the TEMTADS. This approach would forgo the need for flags placed in advance of the cued interrogation phase.

QAPP Worksheet #17: Survey Design and Project Work Flow (continued)

Possible background locations identified from the dynamic survey will also be re-acquired and marked in the field using a different marking method or scheme from what may be used to mark cued survey locations; spray paint may also be used to identify the proposed background locations. The coordinates of emplaced flags will be stored in the survey instrument data collector and downloaded for daily comparison against intended locations by the re-acquisition field team. Flag locations with offsets greater 10 cm from the intended locations will be re-acquired again before data collection commences at that location.

8.2 Perform Cued Interrogation Survey with TEMTADS

Prior to conducting cued surveys, potential background locations identified during the dynamic data processing will be measured, processed, and verified for usability as cued background locations. These locations will be checked in accordance with SOP MR-AC-06-01 (see **Attachment B**). Each background flagged location will have cued measurements performed over the center and offsets at a ½ cart width in each cardinal direction. The set of five measurements will be processed and validated through a comparison criteria detailed in SOP MR-AC-06-01, and the results will be documented and presented as part of the QC documentation. Background locations will be spaced throughout the survey area so that they are easily accessible by survey teams and reflect localized site conditions. Background measurements will be taken approximately every 2 hours, and after any significant changes to field conditions (i.e., immediately following a rainstorm) or equipment (i.e., new field tablet).

9. Validate Advanced Sensor Data

QC checks will be performed in accordance with SOP MR-AC-07-01 (see **Attachment B**). Data will be evaluated to assess whether the MQOs were met in Worksheet #22. An RCA/CA will be conducted and implemented, as necessary, when MQOs are not met.

10. Conduct Cued Data Processing

Data processing will be performed in accordance with SOP MR-AC-07-01 (see **Attachment B**). Background corrections collected during the cued phase will be used to remove the sensor self-signature and soil response from the measured target data. Background corrections will be applied using the closest background (chronologically and spatially) and within approximately 2 hours of the target measurement.

11. Derived Preliminary Prioritized List

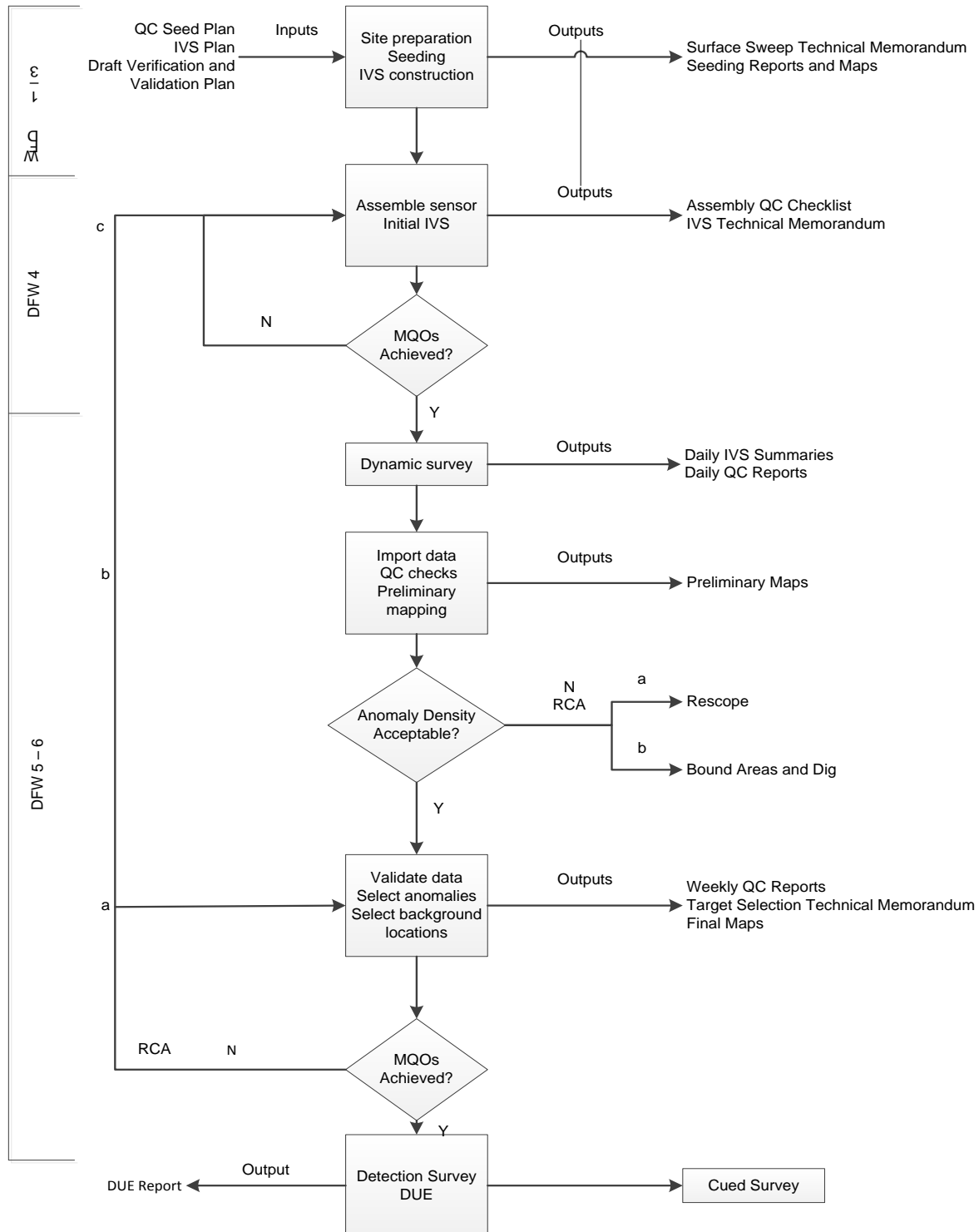
Upon completion of data processing, each anomaly source will be ranked as more or less likely to be a TOI using the library fit correlation metric and a preliminary prioritized list will be provided.

QAPP Worksheet #17: Survey Design and Project Work Flow (continued)

FIGURE 17-1

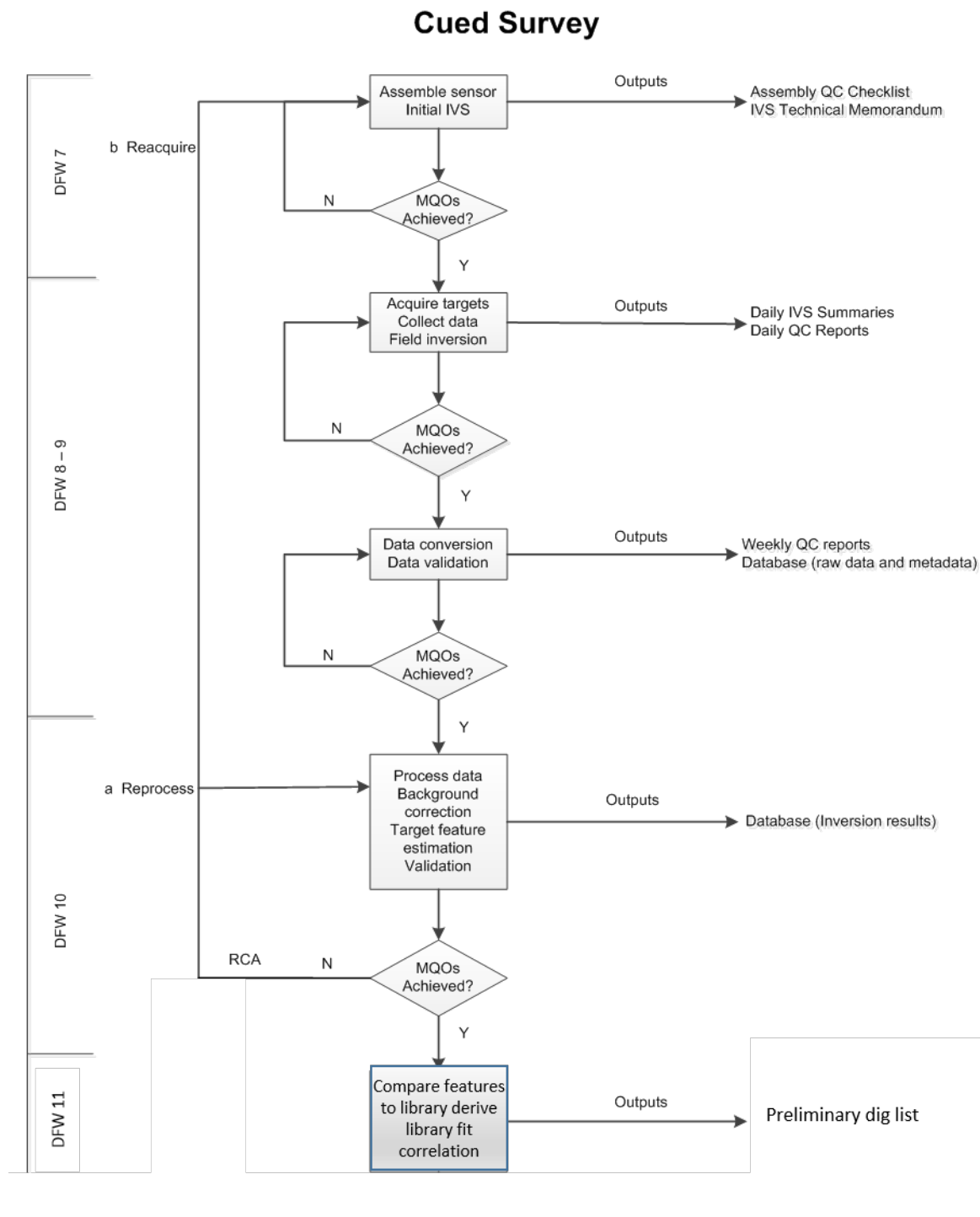
Geophysical Classification Decision Tree

Preliminary Tasks and Anomaly Detection Survey



QAPP Worksheet #17: Survey Design and Project Work Flow (continued)

FIGURE 17-1
 Geophysical Classification Decision Tree (continued)



QAPP Worksheet #22: Equipment Testing, Inspection, and Quality Control

This worksheet documents procedures for performing testing, inspections and QC for all field equipment. References to the applicable DFW and SOPs are included. Where appropriate the failure response will proscribe a CA. Otherwise, an RCA and CA is required.

TABLE 22-1

Dynamic Survey (Instrument: TEMTADS)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
Verify correct assembly	Dynamic Detection Survey MR-AC-01-01	Once following assembly	Field Geophysicist/ Preparatory TEMTADS or EM61 Assembly QC Checklist/QC Geophysicist	As specified in MR-AC-01-01	CA: Make necessary adjustments, and re-verify
Initial TEMTADS Function Test (instrument response amplitudes)	Dynamic Detection Survey MR-AC-02-01	Once following assembly	Field Geophysicist/Initial IVS Technical Memorandum/QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for Schedule 80 small ISO for all monostatic Tx/Rx combinations	CA: Make necessary adjustments, and re-verify
Initial dynamic positioning accuracy (TEMTADS)	Dynamic Detection Survey MR-AC-02-01	Once prior to start of dynamic data acquisition	Data Processing Geophysicist/Initial IVS Technical Memorandum/QC Geophysicist	Derived positions of IVS target(s) are within 0.82 ft (0.25 m) of the ground truth locations	CA: Make necessary adjustments, and re-verify
Ongoing Instrument Function Test (TEMTADS response amplitudes)	Dynamic Detection Survey MR-AC-03-01	Once prior to start of dynamic collection of each grid. Function tests will also be performed at the start and end of each day of data collection or after each time the instrument is turned on.	Data Processing Geophysicist/daily report, running summary/QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all monostatic Tx/Rx combinations	RCA/CA CA assumption: Dataset for sortie fails (Advanced Detection uses all Tx/Rx combinations so all components must pass)
Ongoing dynamic positioning precision (IVS, TEMTADS)	Dynamic Detection Survey MR-AC-03-01	Beginning and end of daily survey operations	Data Processing Geophysicist/daily report, running summary/ QC Geophysicist	Derived positions of IVS target(s) within 0.82 ft (0.25 m) of the average locations	RCA/CA

QAPP Worksheet #22: Equipment Testing, Inspection, and Quality Control (continued)

TABLE 22-1

Dynamic Survey (Instrument: TEMTADS)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
Ongoing dynamic detection response amplitudes (IVS)		Beginning and end of daily survey operations	Data Processing Geophysicist/daily report, running summary/ QC Geophysicist	Response amplitudes within 30% of initial response	
In-line measurement spacing (TEMTADS)	Dynamic Detection Survey MR-AC-03-01	Verified for each survey unit using existing UX Detect tools based upon monostatic Z coil data positions	Data Processing Geophysicist/grid block summary report (MRSIMS)/QC Geophysicist	100% \leq 0.65 ft (0.20 m) between successive measurements (excluding site specific access limitations, e.g., obstacles, unsafe terrain)	RCA/CA CA assumption: data set fails, (recollect portions that fail)
Coverage (TEMTADS)	Dynamic Detection Survey MR-AC-03-01	Verified for each survey unit using existing UX Detect tools based upon monostatic Z coil data	Data Processing Geophysicist/grid block summary report (MRSIMS)/QC Geophysicist	100% at \leq 2.3 ft (0.7 m) cross-track measurement spacing with intended spacing of 1.6 ft (0.5 m) (excluding site specific access limitations, e.g., obstacles, unsafe terrain)	RCA/CA CA assumption: gaps require fill-in lines to achieve required coverage
TEMTADS TX current	Dynamic Detection Survey MR-AC-04-01	Per measurement	Data Processing Geophysicist/grid block summary report (MRSIMS)/QC Geophysicist	Peak transmit current \geq 5.5 amps	CA: out of spec data rejected
Dynamic detection performance (TEMTADS)	Dynamic Detection Survey MR-AC-04-01	Evaluated by survey unit	QC Geophysicist/grid block summary report/Program Geophysicist	All blind seeds must be detected and positioned within 1.3 ft (0.4 m) radius of ground truth	RCA/CA
Dynamic detection performance (EM61)	Dynamic Detection Survey MR-AC-04-01	Evaluated by survey unit	QC Geophysicist/grid block summary report/Program Geophysicist	All blind seeds must be detected and positioned within 1.6 ft (0.5 m) radius of ground truth	RCA/CA

QAPP Worksheet #22: Equipment Testing, Inspection, and Quality Control (continued)

TABLE 22-1

Dynamic Survey (Instrument: TEMTADS)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
Sensor response within valid range	Dynamic Detection Survey MR-AC-04-01	Per measurement	Data Processing Geophysicist/Contractor QC Report, tracking summary/QC Geophysicist	Values must be within ± 4.5 Volts	RCA/CA
Valid position data (1 of 2)	Dynamic Detection Survey MR-AC-04-01	Per measurement	Data Processing Geophysicist/Contractor QC Report, tracking summary/QC Geophysicist	GPS status flag indicates RTK fix (for RTK-GPS enabled surveys)	RCA/CA
TEMTADS Valid position data (2 of 2)	Dynamic Detection Survey MR-AC-04-01	Per measurement	Data Processing Geophysicist/Contractor QC Report, tracking summary/QC Geophysicist	Orientation data valid	RCA/CA
Size and decay rate threshold verification (for Advanced Detection)	Dynamic Detection Survey MR-AC-04-01	Per survey block	Data Processing Geophysicist/Contractor QC Report, tracking summary/QC Geophysicist	QC geophysicist confirms that thresholds are low enough to capture all munitions types expected on site	Re-run advanced detection with correct metrics

QAPP Worksheet #22: Equipment Testing, Inspection, and Quality Control (continued)

Table 22-2

Dynamic Survey (Instrument: EM61)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
Verify correct assembly	Dynamic Detection Survey MR-SS-01-01	Once following assembly	Field Geophysicist/QC Geophysicist	As specified in MR-SS-01-01	CA: Make necessary adjustments, and re-verify
Initial Function Test (EM61 response amplitudes)	Dynamic Detection Survey MR-SS-01-01	Once following assembly	Field Geophysicist/Initial IVS Technical Memorandum/QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for Schedule 40 small ISO for all fixed height above bottom coil	CA: Make necessary adjustments, and re-verify
Initial dynamic positioning accuracy (EM61)	Dynamic Detection Survey MR-SS-01-03	Once prior to start of dynamic data acquisition	Data Processing Geophysicist/Initial IVS Technical Memorandum/QC Geophysicist	Derived positions of IVS target(s) are within 0.5 m (1.7 ft) of the ground truth locations	CA: Make necessary adjustments, and re-verify
Ongoing Function Test (EM61 response amplitudes)	Dynamic Detection Survey MR-SS-01-01	Function tests will be performed at the start and end of each day of data collection Additional function tests may be performed prior to the start of each dynamic data acquisition sortie (dynamic data collection event)	Data Processing Geophysicist/daily report, running summary/QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for Schedule 40 small ISO at fixed height above bottom coil	RCA/CA, as applicable
In-line measurement spacing (EM61)	Dynamic Detection Survey MR-SS-01-01	Verified for each survey unit collected	Data Processing Geophysicist/grid block summary report (MRP Enterprise)/QC Geophysicist	100% \leq 0.25 m (0.82 ft) between successive measurements and no successive measurements have a spacing greater than 0.6 m (2.0 ft) (excluding site specific access limitations, e.g., obstacles, unsafe terrain)	RCA/CA CA assumption: data set fails, (recollect portions that fail)

QAPP Worksheet #22: Equipment Testing, Inspection, and Quality Control (continued)

Table 22-2

Dynamic Survey (Instrument: EM61)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
Coverage (EM61)	Dynamic Detection Survey MR-SS-01-01	Verified for each survey unit collected using fiducial positioning methods	Data Processing Geophysicist/grid block summary report (MRP Enterprise)/QC Geophysicist	No missing lines within survey unit (excluding site specific access limitations, e.g. obstacles, unsafe terrain)	CA: gaps require fill in lines to achieve required coverage
	Dynamic Detection Survey MR-SS-01-01	Verified for each survey unit collected	QC Geophysicist/grid block summary report (MRP Enterprise)/QC Geophysicist	100% cross-line spacing ≤ 1 m (3.3 ft), intended lane spacing is 0.75 m (2.5 ft) (excluding site specific access limitations, e.g., obstacles, unsafe terrain)	CA: gaps require fill-in lines to achieve required coverage
Dynamic detection performance (EM61)	Dynamic Detection Survey MR-SS-01-01	Evaluated by survey unit	QC Geophysicist/grid block summary report (MRP Enterprise)/ Program Geophysicist	All blind seeds must be detected and positioned within a 0.5m (1.6 ft) radius for RTK-GPS enabled surveys: 1 m (3.3 ft) radius of ground truth for fiducially positioned surveys	RCA/CA

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QAPP Worksheet #22: Equipment Testing, Inspection, and Quality Control (continued)

TABLE 22-3
Cued Survey (Instrument: TEMTADS; Classification Tool: UX-Analyze)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
Verify correct assembly	Cued Classification Survey MR-AC-01-01	Once following assembly	Data Processing Geophysicist/Preparatory TEMTADS Assembly QC Checklist/QC Geophysicist	As specified in MR-AC-01-01	CA: Make necessary adjustments, and re-verify
Initial sensor function test	Cued Classification Survey MR-AC-01-01	Once following assembly	Data Processing Geophysicist/Initial IVS Technical Memorandum/QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all monostatic Tx/Rx combinations	CA: make necessary repairs/ adjustments and re-verify
Initial IVS background measurement (five background measurements, one centered at the flag and one offset 40 cm in each cardinal direction)	Cued Classification Survey MR-AC-05-01	Once during initial system IVS test	Data Processing Geophysicist/Initial IVS Technical Memorandum/QC Geophysicist	Data from each offset location, when added to background corrected signal for the project 'item/depth objective' results in a library match metric ≥ 0.9	CA: reject/replace background (BG) location
Initial derived polarizabilities accuracy (IVS)	Cued Classification Survey MR-AC-05-01	Once during initial system IVS test	Data Processing Geophysicist/Initial IVS Technical Memorandum/QC Geophysicist	Library Match metric ≥ 0.9 for each set of inverted polarizabilities	RCA/CA
Initial derived target position accuracy (IVS)	Cued Classification Survey MR-AC-05-01	Once during initial system IVS test	Data Processing Geophysicist/Initial IVS Technical Memorandum/QC Geophysicist	All IVS item fit locations within 0.82 ft (0.25 m) of ground truth locations	RCA/CA
Ongoing IVS background measurements	Cued Classification Survey MR-AC-06-01	Beginning and end of each day as part of IVS testing	Data Processing Geophysicist/Contractor QC Report, tracking summary/QC Geophysicist	All decay amplitudes lower than project threshold and qualitatively agree with initial measurement	RCA/CA CA assumption: rejection of BG measurement (unless RCA indicates system failure)
Ongoing derived polarizabilities precision (IVS)	Cued Classification Survey MR-AC-06-01	Beginning and end of each day as part of IVS testing	Data Processing Geophysicist/ Contractor QC Report, tracking summary/QC Geophysicist	Library Match to initial polarizabilities metric ≥ 0.9 for each set of three inverted polarizabilities	RCA/CA
Ongoing derived target position precision (IVS)	Cued Classification Survey MR-AC-06-01	Beginning and end of each day as part of IVS testing	Data Processing Geophysicist/ Contractor QC Report, tracking summary/QC Geophysicist	All IVS items fit locations within 0.82 ft (0.25 m) of average of derived fit locations	RCA/CA
Initial measurement of production area background locations (five background measurements: one centered at the flag and one offset 40cm in each cardinal direction)	Cued Classification Survey MR-AC-06-01	Once per background location	Data Processing Geophysicist/background location report/QC Geophysicist	Data from each offset location, when added to BG corrected signal for the project 'item/depth objective' results in a library match metric ≥ 0.9	CA: reject BG location and find alternate
Ongoing production area background measurements	Cued Classification Survey MR-AC-06-01	Backgrounds collected once every 2 hours during production	FTL/failures noted in field log and tracking summary/Project Geophysicist	All decay amplitudes lower than project threshold and qualitatively agree with initial measurement	CA: BG measurement rejected and recollected, cued data with no valid BG are rejected
Ongoing instrument function test	Cued Classification Survey MR-AC-06-01	With each background measurement and each time instrument is restarted	FTL/tracking summary/Project Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all monostatic Tx/Rx combinations	CA: make necessary repairs and re-verify
TEMTADS TX current	Cued Classification Survey MR-AC-06-01	Evaluated for each sensor measurement	Data Processing Geophysicist/ Measurement QC summary/QC Geophysicist	Peak transmit current ≥ 5.5 amps	CA: reject data collected with current levels outside of the given range and halt data collection if problem is persistent. Resume collection when problem remedied.
Initial anomaly location interrogated	Cued Classification Survey MR-AC-06-01	Evaluated for each flag position	Data Processing Geophysicist/ Measurement QC summary/QC Geophysicist	For each target a measurement must be collected with the center of the array <1.0 ft (0.3 m) from the target location.	CA: Recollect at anomaly location – (if no collection within spec, anomaly is classified as “Cannot Analyze” and marked for intrusive investigation)

QAPP Worksheet #22: Equipment Testing, Inspection, and Quality Control (continued)

TABLE 22-3
Cued Survey (Instrument: TEMENTADS; Classification Tool: UX-Analyze)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
Position data are valid (1 of 2)	Cued Classification Survey MR-AC-07-01	Evaluated for each sensor measurement (not applicable for cued measurements taken in areas where GPS coverage not available)	Data Processing Geophysicist/ Measurement QC summary/QC Geophysicist	GPS status flag indicates RTK fix	RCA/CA
Position data are valid (2 of 2)	Cued Classification Survey MR-AC-07-01	Evaluated for each sensor measurement	Data Processing Geophysicist/ Measurement QC summary/ QC Geophysicist	Orientation data valid	RCA/CA
Confirm inversion model supports classification (1 of 3)	Cued Classification Survey MR-AC-07-01	Evaluated for all models derived from a measurement (i.e. single item and multi-item models)	Data Processing Geophysicist/ Measurement QC summary/QC Geophysicist	Derived model response must fit the observed data with a fit coherence ≥ 0.8	Follow procedure in SOP or RCA/CA
Confirm inversion model supports classification (2 of 3)	Cued Classification Survey MR-AC-07-01	Evaluated for derived target	Data Processing Geophysicist/ Measurement QC summary/QC Geophysicist	Fit location estimate of item ≤ 1.31 ft (0.4 m) from center of sensor	Follow procedure in SOP or RCA/CA
Confirm all anomalies classified	Cued Classification Survey MR-AC-07-01	Evaluated for each anomaly (flag) location	Data Processing Geophysicist/ Measurement QC summary/ QC Geophysicist	100% of anomalies are included in prioritized list	CA: assign category to anomaly (category 0 [Cannot Analyze] if no valid classification results are available)
Confirm inversion model supports classification (3 of 3)	Cued Classification Survey MR-AC-07-01	Evaluated for all seeds	QC Geophysicist/ Inversion model QC summary/QC Geophysicist	100% of predicted seed positions ≤ 0.82 ft (0.25 m) from known position (x, y, z) if single source anomaly locations and ± 3 cm accuracy positioning of the seed locations recorded upon placement and discovery	RCA/CA

QAPP Worksheet #29: Data Management, Project Documents, and Records

Part 1: Data Management Specifications

GIS: An existing project-specific GIS will be used to store and manage relevant geospatial-related data and information collected as part of the AGCMRRI QAPP. All geospatial data will conform to the FGDC Geospatial Positioning Accuracy Standards, Part 2: NSSDA, and Part 4: Standards for A/E/C and Facility Management. Each GIS data set will be accompanied by metadata conforming to the FGDC CSDGM and provided in a database that complies with the SDSFIE. The final GIS submittal will contain all required ArcGIS.mxd files and layout files for all drawings contained in the final report.

All data will be correlated with navigational data based upon a local third-order (1:5,000) monument or survey marker. All data will be provided in NAD83 CONUS, MDCS, and units of meters.

The location, identification, coordinates, and elevations of control points (newly established or existing) will be plotted on relevant site plans and tabulated in relevant reports submitted throughout the study. Each control point will be identified on the map by its unique identifier (ID).

ESRI-compliant formats (shapefiles, coverages, or geodatabases) will be used to present GIS data, with supporting tabular data provided in Microsoft Excel, Microsoft Access, or both, as needed.

Computer Files and Digital Data: Final document files, including reports, figures, and tables, will be submitted in electronic format (both Microsoft Office 2013 [or later], and PDF via email transmission, secure file transfer protocol (FTP) or secure SharePoint sites. If necessary due to access limitations or file sizes, information will be provided on DVD. FTP and SharePoint sites will be maintained by CH2M. FTP sites will only be used for the transfer of information as needed during the field investigations for the project. The project-specific SharePoint and CH2M secure network servers will be utilized for long-term data storage and secure back up of information.

Native geophysical data files will be provided in accordance with the deliverables requirements in this QAPP and associated SOPs for the various DFWs. Images will be presented in standard graphics formats (.PNG, .JPG) for insertion into documents. The native files may include the following:

- Raw geophysical sensor files
- Raw sensor files formatted for input into Geosoft Oasis Montaj (Geosoft)
- Geosoft database (.GDB) files containing raw data channels and processed data channels
- Geosoft grid (.GRD) and packed map (.MAP) files for data sets where gridding and contouring will be performed as part of generation of a false-color results map
- Exported database files (.XYZ or .CSV) in format readable by Geosoft, including target lists
- Images of QC test results, sensor function test results, background location evaluations (for cued survey)
- Images of polarizabilities and library matching for cued measurements recorded twice daily at the IVS and at anomaly sources selected throughout the study area

QAPP Worksheet #29: Data Management, Project Documents, and Records (continued)

Part 2: Control of Documents, Records, and Databases

Record	Responsible Party for Generation	Responsible Party for Verification	Format(s)/Storage Location
Field Records/Databases			
Geophysical Team Leader Logbook (paper or digital records)	Field Geophysicists	Project Geophysicist	MRSIMS/MRP Enterprise Database, PDF/CH2M Network
QC/Safety Daily Reports (including QC audits)	UXOSO/Quality Control Specialist (QCS)	Task Manager, CH2M PM	Microsoft Word Files/CH2M Network
SUXOS Daily Reports	SUXOS	Task Manager, CH2M PM	Microsoft Word Files/CH2M Network
Photo Documentation	Various	Task Manager, CH2M PM	JPG/CH2M Network
QC Seed Types, Depths, Location	UXOQCS, Surveyor	QC Geophysicist	Microsoft Excel Files/Local drive and Secure SharePoint library (limited to QC personnel)
Validation Seed Types, Depths, Location	Navy	Navy, QC Geophysicist	Microsoft Excel Files/Client storage location (limited to Navy personnel until after intrusive investigation of training and validation digs is performed)
Instrument Assembly Checklists (dynamic and cued surveys)	Field Geophysicists	Project Geophysicist, QC Geophysicist	Microsoft Word, PDF Files/ CH2M Network
IVS Technical Memoranda (dynamic and cued surveys)	QC Geophysicist	Program Geophysicist, CH2M PM	CH2M HILL Network and Secure SharePoint library
UXO Team Leader Logbook (paper or digital records)	UXO Team Leader	Task Manager, UXOQCS, CH2M PM	MRSIMS/MRP Enterprise Database, PDF/CH2M Network
Raw Geophysical Data Packages	Field Geophysicists, Project Geophysicist	Data Processing Geophysicists, QC Geophysicist	Various/CH2M Secure SharePoint library and Network
Processed Geophysical Data Packages	Data Processing Geophysicists, QC Geophysicist	Program Geophysicist, CH2M PM	Various/CH2M Secure SharePoint library and Network
Nonconformance, RCA and CA reports	UXOQCS, QC Geophysicist, Program Geophysicist, CH2M PM	QC Manager	Various/CH2M Secure SharePoint library and Network
Equipment and Instrument Check Logs	Field Geophysicists/ UXO Team Leader	Task Manager, QC Geophysicist,	Various/CH2M Secure SharePoint library and Network

QAPP Worksheet #29: Data Management, Project Documents, and Records (continued)

Part 2: Control of Documents, Records, and Databases (continued)

Record	Responsible Party for Generation	Responsible Party for Verification	Format(s)/Storage Location
Deliverables (Plans, Technical Memoranda, Reports, Databases)			
Blind Seed Firewall Plan	Program Geophysicist	Task Manager, CH2M PM	Microsoft Word Files/CH2M Network and Secure SharePoint library
Surface Sweep Technical Memorandum	SUXOS	Task Manager, CH2M PM	Microsoft Word Files/CH2M Network and Secure SharePoint library
QC Seeding Technical Memorandum	QC Geophysicist	Task Manager, Program Geophysicist, CH2M PM	Microsoft Word Files/CH2M Network and Secure SharePoint library
IVS Technical Memoranda	QC Geophysicist	Task Manager, Program Geophysicist, CH2M PM	Microsoft Word Files/CH2M Network and Secure SharePoint library
Data processing logs (Dynamic and Cued Surveys)	Project Geophysicist, Data Processing Geophysicists	Task Manager, QC Geophysicist, Program Geophysicist, CH2M PM	MRSIMS Database, Various/CH2M Secure SharePoint library and Network
Final Data Delivery Packages (Dynamic and Cued Surveys)	QC Geophysicist	Program Geophysicist, Task Manager, CH2M PM	Various/CH2M Secure SharePoint library and Network
Target Lists for Reacquisition	QC Geophysicist	QC Geophysicist, Task Manager, CH2M PM	Microsoft Excel Files/CH2M Network and Secure SharePoint library
Dynamic Data Analysis and Target Selection Memorandum	QC Geophysicist	Program Geophysicist, Task Manager, CH2M PM	Microsoft Word Files/CH2M Network and Secure SharePoint library
Cued Data Analysis and Preliminary Prioritized List Technical Memorandum	QC Geophysicist	Program Geophysicist, Task Manager, CH2M PM	Microsoft Word Files/CH2M Network and Secure SharePoint library
Supporting Classification Images	QC Geophysicist	Program Geophysicist, Task Manager, CH2M PM	PDF and graphic (.PNG, .JPEG) Files/CH2M Network and Secure SharePoint library
Prioritized Dig List (Preliminary)	QC Geophysicist	Program Geophysicist, Task Manager, CH2M PM	Microsoft Excel Files/CH2M Network and Secure SharePoint library
Report	Program Geophysicist, Task Manager	CH2M PM	Microsoft Word Files/CH2M Network and Secure SharePoint library
Final data archives	Task Manager, Program Geophysicist, SUXOS	CH2M PM	Various/CH2M Secure SharePoint library and Network

QAPP Worksheet #29: Data Management, Project Documents, and Records (continued)

Part 2: Control of Documents, Records, and Databases (continued)

Record	Responsible Party for Generation	Responsible Party for Verification	Format(s)/Storage Location
Project Assessments			
Field Audit Checklists	UXOQCS	Task Manager, Program Geophysicist, CH2M PM	Microsoft Word Files/CH2M Network and Secure SharePoint library
Verification Checklists	Field Geophysicist	Task Manager, QC Geophysicist	Microsoft Word, PDF Files/CH2M Network and Secure SharePoint library
QC Summary Reports and Tracking Summaries During Geophysical Data Processing	Data Processing Geophysicists, QC Geophysicist	Task Manager, Program Geophysicist, CH2M PM	Various/CH2M Secure SharePoint library and Network

Daily QC Reports

Daily work activity summary reports will be maintained by the UXOQCS. These daily reports may include, but are not limited to, the following items:

- QC reports and findings
- H&S reports
- Training logs
- SUXOS reports (including activity log)
- Reports on any emergency response actions
- MEC discovery and classification of the item
- Records of site work and progress

The daily QC reports will be recorded on the Contractor Production Report form provided in **Attachment A**. The daily QC reports provide backup information and are intended to aid in the preparation of the weekly QC report discussed below.

Weekly QC Report

The UXOQCS is responsible for preparing and submitting a weekly QC report to the Program QC Manager and CH2M PM. The weekly QC report is to be submitted to the Program QC Manager on the first workday following the dates covered by the report. The weekly QC report is to provide an overview of QC activities during the week, including those performed by subcontractors. The QC reports must present an accurate and complete picture of QC activities by reporting both conforming and deficient conditions, and the reports should be precise, factual, legible, and objective. Copies of supporting documentation, such as checklists and surveillance reports, are to be attached.

QC and H&S staff input for the weekly QC report is to be provided in writing to the SUXOS at a previously agreed-upon time and place, generally no later than one hour before normal close of business. For the sake of simplicity and completeness, the format for QC staff input should follow the same format as the weekly QC report, with only the relevant sections completed.

Copies of weekly QC reports with attachments and field QC logs no longer in use are to be maintained in the project QC file. Upon project closeout, all QC reports are to be included in the project QC file.

QAPP Worksheet #29: Data Management, Project Documents, and Records (continued)

Part 2: Control of Documents, Records, and Databases (continued)

Field Logbooks

The SUXOS, UXOQCS, and each FTL is responsible for maintaining paginated, bound, and dated hard copy field logbooks or records in MRSIMS/MRP Enterprise handheld devices to record activities that occur each workday. (MRSIMS is described in **Figure 29-1**) UXO teams performing escort and surface sweep activities will use MRSIMS handheld devices to digitally capture, track, and upload data daily into the data management system. Reports will be generated from the data entered so the team leaders can review their entries and correct any discrepancies. Each logbook entry will be event-, area- or site-specific and clearly noted accordingly. At the conclusion of the project, logbook entries will become a permanent part of the contract record.

Safety Logbook

The UXOSO will also maintain a logbook that summarizes daily safety activities. This safety logbook (which may be combined with the QC logbook) will document compliance with the APP. Safety logbooks will be maintained as paginated, bound, and dated hard copy logs or records in MRSIMS/MRP Enterprise handheld devices. The safety logbooks will record such information as the date, the start and stop times of work, weather conditions, the names of field team personnel, specific description of the work being conducted, break times, names and times of visitors to the site, and any incidents or other unusual events that occurred that day. This includes documentation of the performance and content of daily H&S meetings. The APP provides additional details on the safety logbook.

These logbooks will describe conditions or activities leading up to or contributing to a safety incident or lost time due to safety. Safety logbooks will be turned over to the CH2M PM and become a permanent part of the contract record.

Quality Control Logbook

The UXOQCS will maintain a QC logbook (which may be combined with the safety logbook) that summarizes field QC inspections. This logbook will document compliance with this QAPP and specify workmanship acceptability. QC logbooks will be maintained as paginated, bound, and dated hard copy logs or records in MRSIMS/MRP Enterprise handheld devices. The area, the DFW being inspected, and the date will be recorded. Each logbook entry will be event-, area- or site-specific and clearly noted accordingly. QC logbooks will be turned over to the CH2M PM and will become a permanent part of the contract record, in addition to the completed specific QC forms specified above.

Test and Maintenance Records

Any equipment test or maintenance task will be documented in MRSIMS/MRP Enterprise or on an appropriate subcontractor form or field logbook by the individual performing the task. Testing and maintenance of equipment will be performed according to the manufacturer's specifications, this QAPP, and applicable SOPs. Geophysical detection equipment will be tested daily when in use. At a minimum, the test or maintenance log will contain the date and time of the task, equipment name and identification numbers, name of individual performing the task, and results of the task. Upon project closeout, all tests and maintenance records will be included in the project QC file.

The UXOQCS is responsible for ensuring that the tests are performed and that the results are summarized and provided with the weekly QC report. To track each failing test for future retesting, the failing test must be noted on the deficiency log. Resolution of the failing test is complete when retesting is performed and the CA is verified on a deficiency log.

QAPP Worksheet #29: Data Management, Project Documents, and Records (continued)

Part 2: Control of Documents, Records, and Databases (continued)

Training Records

The SUXOS will maintain a file for each site employee to document qualifications and the successful completion of the required training courses for that particular employee. The documentation may be a certificate, letter, memorandum, or other written form of documentation but must include the training completion date(s). If any required refresher training courses do not take place by the anniversary date of the employee's initial training, there should be a record in the employee's file indicating why the training has been delayed and when the training will be completed. The SUXOS will complete Form 4-2 to document employee qualifications and training.

Photographic Logbook

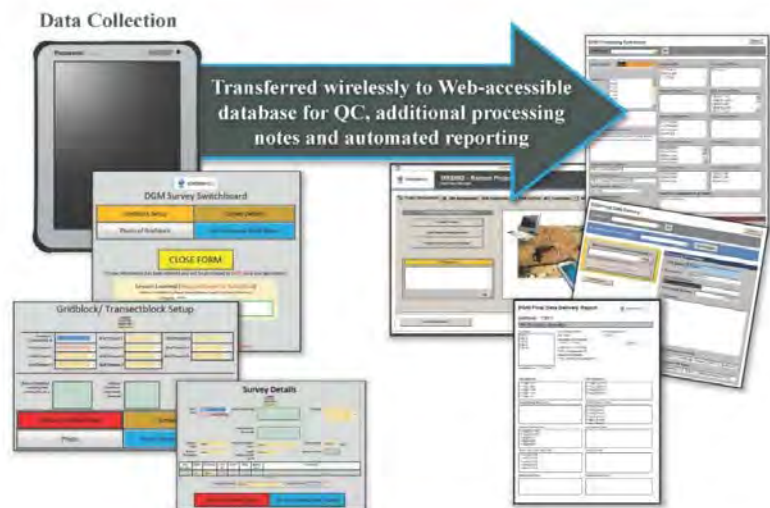
Maintaining a photographic logbook will document the history and evolution of the project. The logbook will be used by the SUXOS, team leaders, and UXOQCS to document the location, date, and subject of each photo taken. MRSIMS/MRP Enterprise forms recording this same information may take the place of or supplement this logbook.

FIGURE 29-1
Munitions Response Site Information Management System

The CH2M HILL Munitions Response Site Information Management System (MRSIMS) is a cradle-to-grave data management system designed to track and easily query metadata for Munitions Response projects.

MRSIMS digitally captures, tracks and creates automated reports on:

- Project Information (e.g. Personnel, Teams, Instrument Serial Numbers, Grid IDs and Locations)
- Field Team Leader Notes (e.g. Safety Meetings, Logbooks, Field Requests to Management)
- Digital Geophysical Mapping and UXO Field Team notes (e.g. Grids, Files, Personnel, Methods, Instruments, MEC Items Found)
- DGM Data Processing Notes and Delivery Data (File Names, Processing Performed, QC of Data, Delivery Dates)
- Grid Statuses (e.g. Activities Performed by Grid and by Acre, Percents and Quantities Complete or Remaining)
- Demolition Tracking (All MEC Items Noted as Needing Demolition or Demilitarization Tracked from Initial Discovery to Final Disposition)
- Quality Control (e.g. QC on Notes, Processing, Data, Comparison of DGM Results to Intrusive Investigation Results and Field Activities)



QAPP Worksheet #31, 32 & 33: Assessments and Corrective Action

This worksheet documents procedures for performing testing, inspections and QC for all field equipment. References to the applicable DFW and SOPs are included. Where appropriate the failure response will proscribe a CA. Otherwise, an RCA and CA is required.

Three Phases of Control

The UXOQCS is responsible for verifying onsite compliance with this portion of the QAPP through implementation of a three-phase control process, which ensures that project activities comply with the approved plans and procedures. The QC Geophysicist is responsible for compliance with portions of the QAPP which address achievement of MQOs and QC requirements pertaining to geophysical data. The CH2M PM is responsible for overall compliance with the QAPP. The specific QC monitoring requirements for each DFW are discussed below. This section specifies the minimum requirements that must be met and to what extent QC monitoring must be conducted and documented by the responsible party.

The responsible parties will ensure that the three-phase control process is implemented for each DFW. Each phase is considered relevant for obtaining necessary product quality. However, the preparatory and initial inspections are particularly invaluable in preventing problems. Work will not be performed on a DFW until the preparatory and initial phase inspections have been completed and any non-conformance issues are resolved.

Preparatory Phase Inspection

The Preparatory Phase (PP) comprises the planning and design process leading up to the actual field activities. The UXOQCS, QC Geophysicist, CH2M PM, or other designated responsible party will perform a PP inspection before beginning each DFW. The purposes of this inspection are to review applicable specifications and plans to verify that the necessary resources, conditions, and controls are in place and compliant before work activities start. Upon completion of the inspection, the UXOQCS will be responsible for completion of the Contractor QC Report and PP Report provided in **Attachment A**.

To perform the inspection, the responsible parties will review the appropriate sections of the QAPP. The CH2M PM will verify that required plans and procedures have been approved and are available to the field staff; field equipment is appropriate, available, functional, and properly tested for its intended/stated use; staff responsibilities have been assigned and communicated; the staff members have the necessary knowledge, expertise, and information to perform their jobs; arrangements for support services have been made; training in accordance with the requirements of this QAPP has occurred; and the prerequisite mobilization tasks have been completed.

Project personnel must correct or resolve discrepancies, as needed, between existing conditions and the approved QAPP identified during the PP inspection. The appropriate responsible party will verify that unsatisfactory and/or nonconforming conditions have been corrected before beginning work.

Initial Phase Inspection

The Initial Phase (IP) occurs at the startup of field activities associated with a specific DFW. At the onset of a particular DFW, the responsible parties will perform an IP inspection, and the UXOQCS will be responsible for completion of the Contractor QC Report provided in **Attachment A**. The main objectives of the inspection are to check preliminary work for compliance with procedures and specifications, establish an acceptable level of workmanship, check for omissions, and resolve differences of interpretation. The IP inspection will also verify that the SSHP adequately identifies all hazards associated with actual field conditions and promulgates the appropriate safe work practices. The inspection results will be documented by the UXOQCS in the daily report. Should results of the inspection be unsatisfactory, the Initial Phase will be rescheduled and performed again.

QAPP Worksheet #31, 32 & 33: Assessments and Corrective Action (continued)

During the IP inspection, the appropriate responsible party will ensure that discrepancies between site practices and approved plans or specifications are identified and resolved. The resolution of discrepancies is a critical step in the IP inspection. As applicable, other team members (Project Geophysicist, QC Geophysicist, SUXOS, etc.) will guide the CH2M PM and UXOQCS in resolving discrepancies. If discrepancies arise in establishing the baseline quality for a DFW, the responsibility for resolution falls to the CH2M PM. If the discrepancy cannot be resolved in a manner that satisfies the project requirements, it will be elevated to the program level (to the Activity Manager or Activity Quality Manager [AQM]), and a Non-Conformance Report (NCR) will be issued. With concurrence of the CH2M team, the appropriate responsible party may direct a cessation of work activity if an unresolved discrepancy jeopardizes the results of the DFW or puts the project at risk of non-conformance.

Follow-up Phase Inspection

Completion of the Initial Phase of QC activity leads directly into the Follow-up Phase (FP), which covers the routine day-to-day activities at the site. Responsible parties will perform an FP inspection at regular intervals while a particular DFW is performed. This inspection ensures continuous compliance and verifies an acceptable level of workmanship. To conduct and document these inspections, the UXOQCS will complete the Contractor QC Report provided in **Attachment A**. The UXOQCS will monitor onsite practices and operations taking place and verify continued compliance with the specifications and requirements of this QAPP and approved amendments. The UXOQCS will also verify that daily H&S inspections are performed and documented as prescribed in the SSHP. As applicable, other team members (Project Geophysicist, QC Geophysicist, SUXOS, etc.) will guide the CH2M PM and UXOQCS in resolving discrepancies. Discrepancies between site practices and approved plans/procedures will be resolved, and CAs for unsatisfactory and nonconforming conditions or practices will be resolved by the appropriate responsible party before continuing work.

Additional Inspections

Additional inspections performed on a particular DFW may be required at the discretion of the Navy, the CH2M PM, the SUXOS, the Project and QC Geophysicists, or the UXOQCS. Additional preparatory and initial inspections would be warranted under the following conditions: unsatisfactory work, as determined by CH2M or the Navy; changes in key personnel; resumption of work after a substantial period of inactivity (two weeks or more); or changes to the project scope of work. These additional inspections will be documented on the appropriate inspection checklist forms and in the Contractor QC Report.

Final Phase Inspection

The Final Phase inspection is performed upon conclusion of the DFW and before closeout to verify that project requirements relevant to the particular DFW have been satisfied. Outstanding and nonconforming items will be identified and documented on the Contractor QC Report provided in **Attachment A**.

Notification of Definable Features of Work and Three Phases of Control

The appropriate responsible party will ensure that the three-phase control process is implemented for each DFW listed in **Table 31-1**. Implementation and tracking of the DFWs will be accomplished through the use of Form 4-3 (Inspection Schedule and Tracking Form) provided in **Attachment A**. The assessment schedule, responsible parties, and idealized time frames for completing assessments are also provided in **Table 31-1**.

QAPP Worksheet #31, 32 & 33: Assessments and Corrective Action (continued)

Audit Procedures

The CH2M PM is responsible for verifying compliance with this QAPP through audits and surveillance. The CH2M PM is required to inspect/audit the quality of work being performed for each DFW and verify that the work practices conform to the specifications of this QAPP, unless the CH2M PM designates another responsible party to perform inspections and audits. Discrepancies are to be communicated to the responsible individual and documented in the daily and weekly QC reports. CAs are to be verified by the proper responsible party and recorded in the weekly QC report.

The Inspection Schedule and Tracking Form (Form 4-3, **Attachment A**) is to be used by the CH2M PM for planning, scheduling, and tracking the progress of audits. The information on the form is to be current and reviewed by the CH2M PM. Audit activities and CAs are to be documented by the CH2M PM as described with this section and the audit records are to be maintained as part of the project QC file.

Preventative and Corrective Actions

The preventative and corrective actions incorporated within this QAPP are designed to prevent and correct quality problems that may arise during the RI. The procedures facilitate process improvements and describe the available mechanisms to identify, document, and track discrepancies until a CA has been verified.

Continual Improvement

A continual improvement process will be implemented for the project. Project staff at all levels will be encouraged to provide recommendations for improvements in established work processes and techniques. The intent is to identify activities that are compliant but can be performed in a more efficient or cost-effective manner. Typical quality improvement recommendations include identifying an existing practice that can and should be improved (e.g., a bottleneck in production) and/or recommending an alternative practice that provides a benefit without compromising prescribed standards of quality. Project staff should bring their recommendations to the attention of the responsible party through verbal or written means.

Deviations from established protocols will not be implemented without prior written approval.

Deficiency Identification and Resolution

While deficiency identification and resolution occurs primarily at the operational level, QC audits provide a backup mechanism to address problems that either are not identified or cannot be resolved at the operational level. Through implementation of the audit program prescribed in this QAPP, the CH2M team is responsible for verifying that deficiencies are identified and documented as prescribed herein and corrected in a timely manner. Deficiencies identified by the CH2M team are to be corrected by operational staff and documented by the appropriate responsible party.

Corrective Action Request

A CAR (**Attachment A**) can be issued by any member of the CH2M team, including subcontractor employees. If the individual issuing the CAR is also responsible for correcting the problem, then he/she should document the results on Part B of the CAR. Otherwise, the CAR should be forwarded to the CH2M PM who is then responsible for evaluating the validity of the request, formulating a resolution and developing a corrective strategy, assigning personnel and resources, and specifying and enforcing a schedule for CAs. Once a CA has been completed, the CAR and supporting information will be forwarded to the Program QC Manager for closure. Sufficient information will be provided to allow the QC reviewer to verify the effectiveness of the CAs.

QAPP Worksheet #31, 32 & 33: Assessments and Corrective Action (continued)

The recommendations provided in the CARs and implemented on the project will be reviewed during Follow-Up QC inspections. The purposes of this CAR review are to ensure that established protocols are implemented properly; verify that CA commitments are met; ensure that CAs are effective in resolving problems; identify trends within and among similar work units; and facilitate system RCA of larger problems.

The CH2M PM will determine whether a written CAP (**Attachment A**) is necessary, based on whether or not any of the following are met: the CAR priority is high; deficiency requires a rigorous CA planning process to identify similar work product or activities affected by the deficiency; or deficiency requires extensive resources and planning to correct the deficiency and to prevent recurrence. The CAP will be developed by the CH2M PM and approved and signed by the CH2M PM. The CAP will indicate whether it is submitted for informational purposes or for review and approval. In either event, operational staff are encouraged to discuss CA strategy with the UXOQCS throughout the process.

Corrective Action Request Tracking

Each CAR will be given a unique identification number and tracked until CAs have been implemented in the field, documented in Part B of the CAR form (**Attachment A**) and the CAR is submitted to the CH2M PM for verification and closure.

Lessons Learned and Other Documentation

The lessons learned through the discrepancy management process are documented on CARs and CAPs. To share the lessons learned, these documents will be submitted to the Navy through a Weekly QC Report, which summarizes the week's QC activities and includes a grouping of applicable Daily QC Reports (**Attachment A**) and any other pertinent reports created during the week.

CARs will be cited in the Weekly QC Report. Minor deficiencies identified during a QC audit that are readily correctable and can be verified in the field will be documented in the QC logbook and Weekly QC Report without initiating a CAR. Discrepancies that cannot be readily corrected will be documented by the UXOQCS on a CAR and in the Weekly QC Report. As applicable, other team members (Project Geophysicist, QC Geophysicist, SUXOS, etc.) will guide the UXOQCS in documenting these occurrences. Copies of CARs will be referenced in and attached to the Weekly QC Report. CAPs will also be attached to Weekly QC Reports to document the final outcome of the deficiency. Similar or related deficiencies may be addressed on a single CAP.

QAPP Worksheet #31, 32 & 33: Assessments and Corrective Action (continued)

TABLE 31-1
Assessment Schedule; Assessment Response and Corrective Action

DFW	QC Phase	Task with Auditable Function	Responsibility for Conducting Audit	Frequency of Audit	Audit Procedure	Pass/Fail Criteria	Action if Failure Occurs	Audit Deliverable	Audit Deliverable Due Date	Responsibility for responding to assessment findings	Assessment Response Documentation and Timeframe	Responsibility for Implementing CA	Responsible for Monitoring CA implementation
Pre-mobilization Activities	PP	GCMR QAPP, SSHP	UXOQCS	Once	Verify the Project QAPP and SSHP have been developed and approved	Documents approved, all parties agree to the technical and operational approach	Do not proceed with field activities until criterion is passed	PP Report; Contractor QC Report (Attachment A)	Day of audit	CH2M PM	RCA/CA; Email or other Written Communication, As Appropriate Within 3 days	CH2M PM	UXOQCS
	PP	GIS Setup	UXOQCS	Once	Verify GIS system is functional and ready for site data	GIS system has been set up and is ready for site data	Do not proceed with field activities until criterion is passed		Day of audit	CH2M PM		CH2M PM	Program Geophysicist
	PP	MRSIMS Setup	UXOQCS	Once	Verify MRSIMS system is functional and ready for site data	MRSIMS system has been set up and is ready for site data	Do not proceed with field activities until criterion is passed		Day of audit	Project Geophysicist		Project Geophysicist	Program Geophysicist
	PP/IP	Subcontractor Procurement	UXOQCS	Once	Ensure procurement of subcontractors and verify qualifications, training, licenses	Subcontractors' qualifications, training, and licenses are up to date and acceptable	Be sure subcontractor provides qualifications, training, and licenses or change subcontractor		Day of audit	CH2M PM		CH2M PM	UXOQCS
Mobilization/ Site Preparation	PP/IP/FP	Daily UXO Safety Briefing	UXOQCS	Daily	Confirm that the UXOSO or representative conducted a daily safety briefing and all field personnel acknowledged by signature	UXOSO or representative conducted a daily safety briefing and all field personnel acknowledged it by signature	Those personnel not receiving a safety briefing are not authorized in the exclusion zone until it is received and acknowledged by signature	PP Report; Contractor QC Report (Attachment A)	Daily	SUXOS	RCA/CA Within 1 day	UXOSO	UXOQCS
	PP/IP	Onsite Document Review	UXOQCS	Once	Verify QAPP and SSHP approved and review with project team and get appropriate signatures	Documents approved and reviewed and acknowledged by appropriate project team members	Personnel who are not familiar with the QAPP may not proceed with field activities until criterion are passed		Day of audit	CH2M PM, Program Geophysicist, SUXOS		CH2M PM, Project Geophysicist, SUXOS	UXOQCS, Program Geophysicist
	PP/IP	Establish Communication and Logistics	UXOQCS	Once	Verify functionality of communications equipment and logistical support is coordinated	Communications and other logistical support are coordinated	Do not proceed with field activities until criterion is passed		Day of audit	CH2M PM, SUXOS		CH2M PM, SUXOS	UXOQCS
	PP/IP	Local Agencies and Emergency Services Notification	UXOQCS	Once	Verify that local agencies and emergency services have been notified of site activities	Emergency services and local agencies are aware of site activities	Do not proceed with field activities until criterion is passed		Day of audit	CH2M PM, SUXOS		CH2M PM, SUXOS	UXOQCS

QAPP Worksheet #31, 32 & 33: Assessments and Corrective Action (continued)

TABLE 31-1
Assessment Schedule; Assessment Response and Corrective Action

DFW	QC Phase	Task with Auditable Function	Responsibility for Conducting Audit	Frequency of Audit	Audit Procedure	Pass/Fail Criteria	Action if Failure Occurs	Audit Deliverable	Audit Deliverable Due Date	Responsibility for responding to assessment findings	Assessment Response Documentation and Timeframe	Responsibility for Implementing CA	Responsible for Monitoring CA implementation
Mobilization/ Site Preparation (con't)	PP/IP	Verify site-specific training	UXOQCS	Once	Verify that all site-specific training has been performed and acknowledged	Site-specific training is performed and acknowledged	Do not proceed with field activities until criterion is passed	PP Report; Contractor QC Report (Attachment A)	Day of audit	CH2M PM, SUXOS	RCA/CA; Email or other Written Communication, As Appropriate Within 3 days	CH2M PM, SUXOS	UXOQCS
	PP/IP	Site Boundary and Grids Establishment	UXOQCS	Once	Verify area/boundary and grids have been properly established	Area/boundary is correct, grids are correct and stakes are appropriately labeled	Stop activities until area/ boundary/ grids are verified as correct		Day of audit	Project Geophysicist		Project Geophysicist	UXOQCS
	PP/IP	Material documented as safe (MDAS) Storage Area	UXOQCS	Once	Verify the material documented as safe (MDAS) storage area is established, containers are marked and securable and personnel have been trained on its proper use	Inspect and document the MDAS storage area meets Federal and State requirements	Do not proceed with intrusive activities until criterion is passed		Day of audit	SUXOS	RCA/CA; Email or other Written Communication, As Appropriate Within 1 day	SUXOS	UXOQCS
Surface Sweep	IP/FP	Daily UXO Safety Briefing	UXOQCS	Daily	Confirm that the UXOSO or representative conducted a daily safety briefing and all field personnel acknowledged by signature	The UXOSO or representative conducted a daily safety briefing and all field personnel acknowledged it by signature	Those personnel not receiving a safety briefing are not authorized in the exclusion zone until it is received and acknowledged by signature.	Contractor QC Report (Attachment A)	Daily	SUXOS	RCA/CA Within 1 day	UXOSO	UXOQCS
	IP/FP	Handheld Metal Detector Daily Checks	UXOQCS	Daily	Verify personnel conduct equipment checks and the detector is serviceable by visually observing the checks by team members and documenting the checks in the logbook	Personnel did conduct equipment check, the detector is serviceable, detector functioning is acceptable and the team leader has made the logbook entry	Repair or replace a malfunctioning instrument. Make the logbook entries.		Daily if performed	SUXOS/UXO Team Leader	RCA/CA Within 1 day	SUXOS/UXO Team Leader	UXOQCS
	IP/FP	Personnel are wearing proper personal protective equipment (PPE) for the task to be performed	UXOSO, UXOQCS	Daily	Confirm personnel are wearing appropriate PPE for the assigned task. UXOQCS or UXOSO to perform daily spot checks	Personnel are wearing appropriate PPE for the assigned task. UXOQCS has filled out the QC Inspection Checklist documenting the spot check(s)	Stop the activities until personnel are wearing the proper PPE Make the logbook entries. Notify the UXOSO of the violation		Weekly	CH2M PM, SUXOS	RCA/CA Within 1 day	CH2M PM, SUXOS	UXOSO/UXOQCS

QAPP Worksheet #31, 32 & 33: Assessments and Corrective Action (continued)

TABLE 31-1
Assessment Schedule; Assessment Response and Corrective Action

DFW	QC Phase	Task with Auditable Function	Responsibility for Conducting Audit	Frequency of Audit	Audit Procedure	Pass/Fail Criteria	Action if Failure Occurs	Audit Deliverable	Audit Deliverable Due Date	Responsibility for responding to assessment findings	Assessment Response Documentation and Timeframe	Responsibility for Implementing CA	Responsible for Monitoring CA implementation
Surface Sweep (con't)	IP/FP	Surface Clearance	UXOQCS	Daily	Verify performed in accordance with QAPP and associated SOPs Confirm that MEC/MPPEH, metal pieces $\geq 2''$ in any dimension and surface QC seeds placed in the area worked were located and returned to the UXOQCS	QC failure if 1 seed, MEC or MPPEH; or ≥ 5 metal pieces $\geq 2''$ in any dimension found in a transect	UXOQCS meet with SUXOS and UXO Team Leader, issues NCR to UXO Team Leader, RCA UXO Team resweeps the failed work area; re-inspection failure requires CAR and CAP Repeated failures may result in stop work order	Contractor QC Report (Attachment A)	Daily if performed	SUXOS/UXO Team Leader	RCA/CA Within 1 day	SUXOS/UXO Team Leader	UXOQCS
	IP/FP	Recovery of QC Seeds	UXOQCS	Daily	Confirm that all surface QC seeds in area worked were recovered and returned to the UXOQCS	QC failure if a surface QC seed in the area worked is not recovered and returned to the UXOQCS	UXOQCS meet with SUXOS and UXO Team Leader, issues NCR to UXO Team Leader, RCA UXO Team resweeps the failed work area; re-inspection failure requires CAR and CAP Repeated failures may result in stop work order		Daily if performed	SUXOS/UXO Team Leader	RCA/CA Within 1 day	SUXOS/UXO Team Leader	UXOQCS
	IP/FP	EZ Boundaries	UXOSO, UXOQCS	Daily	UXOSO verify that signs are in place to identify the work site exclusion zone UXOQCS to perform daily spot checks	Signs are in place to identify the work site exclusion zone	Stop operations until signs are put in place		Daily if performed	CH2M PM, SUXOS	RCA/CA Within 1 day	SUXOS/UXO Team Leader	UXOQCS
Conduct Validation Seeding, QC Seeding, and Construct IVS	PP/IP	Placement of QC Seeds (surface)	UXOQCS; QC Geophysicist	Once/Daily/As Required	Verify QC seeds have been properly placed and their positions properly recorded	QC seeds have been properly placed and positions recorded by the UXOQCS	Do not proceed with surface sweep for an area that does not have QC seeds appropriately placed and locations recorded	PP Report; Contractor QC Report (Attachment A)	Daily if performed	Project Geophysicist	Email or other Written Communication Within 1 day	UXOQCS; QC Geophysicist	CH2M PM; Program Geophysicist
	PP/IP	Placement of QC Seeds (subsurface)		Once/Daily/As Required	Verify QC seeds have been properly placed and their positions properly recorded	QC seeds have been properly placed, covered, documented, and surveyed by the PLS	Do not proceed with dynamic surveys until QC seeds have been appropriately placed and recorded		Daily if performed				

QAPP Worksheet #31, 32 & 33: Assessments and Corrective Action (continued)

TABLE 31-1
Assessment Schedule; Assessment Response and Corrective Action

DFW	QC Phase	Task with Auditable Function	Responsibility for Conducting Audit	Frequency of Audit	Audit Procedure	Pass/Fail Criteria	Action if Failure Occurs	Audit Deliverable	Audit Deliverable Due Date	Responsibility for responding to assessment findings	Assessment Response Documentation and Timeframe	Responsibility for Implementing CA	Responsible for Monitoring CA implementation
Conduct Validation Seeding, QC Seeding, and Construct IVS (con't)	PP	Instrument Verification Strip Construction		Once	Verify that IVS is constructed in accordance with QAPP	IVS constructed in accordance with QAPP	Do not proceed with IVS until IVS is properly constructed or alternate construction is approved by Navy RPM	PP Report; Contractor QC Report (Attachment A)	Once	Project Geophysicist	Email or other Written Communication Within 1 day	UXOQCS; QC Geophysicist	CH2M PM; Program Geophysicist
Assemble and Verify Correct Operation of Geophysical Sensor to be Used for Detection Survey	PP	Assemble sensor	UXOQCS; Lead Field Geophysicist; QC Geophysicist	Once/As Required	Observe assembly and initial function testing of TEMTADS and/or EM61 and completion of checklist	System assembled in accordance with SOP	Do not proceed with IVS until system is properly assembled	PP Report; Contractor QC Report (Attachment A) SOP MR-AC-01-01 Checklist	Within 24 hours of Completion of Each Event	Project Geophysicist	Email or other Written Communication Within 1 day	UXOQCS; Lead Field Geophysicist	CH2M PM; QC Geophysicist
Dynamic Detection Survey	PP/IP/FP	Daily UXO Safety Briefing	UXOQCS	Daily	Confirm that the UXOSO or representative conducted a daily safety briefing and all field personnel acknowledged by signature	UXOSO or representative conducted a daily safety briefing and all field personnel acknowledged it by signature	Those personnel not receiving a safety briefing are not authorized in the exclusion zone until it is received and acknowledged by signature	PP Report; Contractor QC Report (Attachment A)	Daily	SUXOS	RCA/CA Within 1 day	UXOSO	UXOQCS
	PP/IP/FP	Personnel are wearing proper PPE for the task to be performed	UXOSO, UXOQCS	Daily	Confirm personnel are wearing appropriate PPE for the assigned task UXOQCS or UXOSO to perform daily spot checks	Personnel are wearing appropriate PPE for the assigned task UXOQCS has filled out the QC Inspection Checklist documenting the spot check(s)	Stop the activities until personnel are wearing the proper PPE Make the logbook entries Notify the UXOSO of the violation		Daily if performed	CH2M PM, SUXOS	RCA/CA Within 1 day	CH2M PM, SUXOS	UXOSO/UXOQCS
	IP/FP	IVS Performance	QC Geophysicist	Daily/As Required	Verify that IVS related MQOs are being met	MQOs are being met	RCA/CA	Contractor QC Report (Attachment A)	Daily if performed	Lead Data Processor	RCA/CA Within 1 day	Lead Field Geophysicist; Lead Data Processor	CH2M PM; QC Geophysicist
	IP/FP	Dynamic detection survey	QC Geophysicist	Daily/As Required	Verify that dynamic detection related MQOs are being met	MQOs are being met	RCA/CA		Daily if performed	Lead Data Processor	RCA/CA Within 1 day	Lead Field Geophysicist; Lead Data Processor	CH2M PM; QC Geophysicist
Process Dynamic Survey Data and Document Anomaly Locations	IP/FP	Process and interpret dynamic data	QC Geophysicist	Daily	Verify that MQOs are being met	MQOs are being met	RCA/CA	Delivered Geophysical Data Sets Having Undergone QC	Within 3 working days of data collection	Lead Data Processor	RCA/CA Within 1 day	Lead Data Processor	CH2M PM; QC Geophysicist

QAPP Worksheet #31, 32 & 33: Assessments and Corrective Action (continued)

TABLE 31-1
Assessment Schedule; Assessment Response and Corrective Action

DFW	QC Phase	Task with Auditable Function	Responsibility for Conducting Audit	Frequency of Audit	Audit Procedure	Pass/Fail Criteria	Action if Failure Occurs	Audit Deliverable	Audit Deliverable Due Date	Responsibility for responding to assessment findings	Assessment Response Documentation and Timeframe	Responsibility for Implementing CA	Responsible for Monitoring CA implementation
Assemble Advanced Geophysical Sensor and Test Sensor at IVS	PP	Assemble sensor	UXOQCS; Lead Field Geophysicist; QC Geophysicist	Once/As Required	Observe assembly and initial function testing of TEMENTADS in cued interrogation mode and completion of checklist	System assembled in accordance with SOP	Do not proceed with IVS until system is properly assembled	PP Report; Contractor QC Report (Attachment A) SOP MR-AC-01-01 Checklist	Within 24 hours of Completion of Each Event	Project Geophysicist	Email or other Written Communication Within 1 day	UXOQCS; Lead Field Geophysicist	CH2M PM; QC Geophysicist
Cued Survey	PP/IP/FP	Daily UXO Safety Briefing	UXOQCS	Daily	Confirm that UXOSO or representative conducted a daily safety briefing and all field personnel acknowledged by signature	UXOSO or representative conducted a daily safety briefing and all field personnel acknowledged it by signature	Those personnel not receiving a safety briefing are not authorized in the exclusion zone until it is received and acknowledged by signature	PP Report; Contractor QC Report (Attachment A)	Daily	SUXOS	RCA/CA Within 1 day	UXOSO	UXOQCS
	IP/FP	Instrument Verification Strip	QC Geophysicist	Once/Daily/As Required	Verify IVS related MQOs are being met	MQOs are being met	RCA/CA	Contractor QC Report (Attachment A)	Daily if performed	Lead Data Processor	RCA/CA Within 1 day	Project Geophysicist; Lead Data Processor	CH2M PM; QC Geophysicist
	IP/FP	Cued survey	QC Geophysicist	Once/Daily/As Required	Verify cued survey related MQOs are being met	MQOs are being met	RCA/CA		Daily if performed	Lead Data Processor	RCA/CA Within 1 day	Project Geophysicist; Lead Data Processor	CH2M PM; QC Geophysicist
Validate Advanced Sensor Data	IP/FP	QC and Evaluation of Cued data	QC Geophysicist	Daily	Verify cued data are being reviewed daily and that MQOs are being met	MQOs are being met.	RCA/CA	Delivered Geophysical Data Sets Having Undergone QC	As Delivered	Lead Data Processor	RCA/CA Within 1 day	Lead Data Processor; QC Geophysicist	CH2M PM; Project Geophysicist
Conduct Cued Data Processing	IP/FP	Process and interpret Cued data	QC Geophysicist	Once/Daily/As Required	Verify cued processing related MQOs are being met	MQOs are being met	RCA/CA	Delivered Geophysical Data Sets Having Undergone QC	Within 3 working days of data collection	Lead Data Processor	RCA/CA Within 1 day	Lead Data Processor	CH2M PM; QC Geophysicist

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QAPP Worksheet #34: Data Verification, Validation, and Usability Inputs

This worksheet is used to list the inputs that will be used during data verification, validation, and usability assessment. Inputs include all required documents (e.g. contracts, SOPs, planning documents), field records (both hard copy and electronic), and interim and final reports. Data verification is a completeness check that all specified activities involved in data collection and processing have been completed and documented and that the necessary records (objective evidence) are available to proceed to data validation. Data validation is the evaluation of conformance to stated requirements.

Requirements/Specifications:

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)	Usability (Achievement of DQOs and MPCs)
Field Records				
1	PP Report and Contractor QC Report (Attachment A)	X	X	
2	Contractor QC Report (Attachment A)	X	X	
3	Weekly QC Report	X	X	
4	Field logbooks (Safety and Data Collection)	X		
5	Photographs	X		
6	Instrument Assembly Checklist (Dynamic Survey)	X	X	X
7	IVS Construction Details	X	X	
8	IVS Construction Checklist	X	X	
9	Digital Field Notes (MRSIMS/MRP Enterprise entries)	X		
10	Instrument Assembly Checklist (Cued Survey)	X	X	
Electronic Data				
11	Raw TEMTADS (.TEM) or EM61 (.P61 or .R61) data files (EMI, GPS, and inertial measurement unit [IMU])	X	X	
12	Converted TEMTADS or EM61 (ASCII.csv or ASCII.xyz) files	X	X	
13	Data Processing and QC Log (Detection Survey)	X	X	X
14	Digital Field Notes	X	X	X
15	Mapped Detection Metric Data	X	X	X
16	Advanced Detection Target List	X	X	
17	Final Data Archive (for each delivered subset)	X	X	

QAPP Worksheet #34: Data Verification, Validation, and Usability Inputs (continued)

Requirements/Specifications:

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)	Usability (Achievement of DQOs and MPCs)
Interim and Final Reports/Deliverables				
20	SOPs	X		X
21	Blind Seed Firewall Plan	X		X
22	Draft Validation Plan	X		X
23	Final Validation Plan	X		X
24	Surface Sweep Technical Memorandum	X	X	X
25	QC Seeding Technical Memorandum	X	X	X
26	Initial IVS Technical Memorandum	X	X	X
27	Dynamic Data Analysis and Advanced Detection Target Selection Memorandum	X		X
28	IVS Technical Memorandum	X	X	X
29	Cued Data Analysis and Preliminary Prioritized List Technical Memorandum	X		X

QAPP Worksheet #35: Data Verification and Validation Procedures

This worksheet documents procedures that will be used to verify and validate project data. Data verification is a completeness check to confirm that all required activities were conducted, all specified records are present, and the contents of the records are complete. Data validation is the evaluation of conformance to stated requirements.

Activity and Records Reviewed	Requirements/ Specifications	Process Description/Frequency	Responsible Person	Documentation
Field Logbooks	QAPP	A QC logbook (which may be combined with the safety logbook) will summarize field efforts and QC inspections. All information is complete for each day of field activities. Required signatures are present.	UXOQCS; Lead Field Geophysicist	Contractor QC Report (Attachment A)
Validation and QC Seeding	QAPP	Seed items are buried IAW specifications in QAPP. Seed item details (ID, type, orientation, and depth) are documented and items are photographed prior to burial. Seed item locations are surveyed and covered prior to geophysical data collection.	UXOQCS; Project Geophysicist	Daily QC Report; Digital file (.XLS or .CSV) tabulated seed details and locations.
Digital Field Notes	QAPP	Digital field notes for geophysical survey activities may be submitted in conjunction with (or in lieu of) hard copy notes, when applicable. All information is complete for each day of field activities	Lead Field Geophysicist	MRSIMS/MRP Enterprise Entries; Digital notes files in .CSV format
Instrument Assembly	QAPP; SOP MR-AC-01-01; SOP MR-SS-01-01	Instrument Assembly has been completed according to SOP MR-AC-01-01 and MR-SS-01-01 for both dynamic detection and cued surveys. MQOs have been achieved, with any exceptions noted. If appropriate, CAs have been completed. Signatures and dates are present.	Lead Field Geophysicist	SOP 01-01 Checklist, Contractor QC Report (Attachment A)
IVS Construction and Initial Dynamic and Cued Surveys at IVS	QAPP; SOP MR-AC-02-01; SOP MR-AC-05-01; SOP MR-SS-01-01	Initial IVS Survey has been constructed and surveyed according to SOP MR-AC-02-01, SOP MR-AC-05-01, and SOP MR-SS-01-01. Checklist MR-AC-02-01 has been completed. All specifications have been achieved, or exceptions noted. If appropriate, CAs have been completed. Signatures and dates are present.	Lead Field Geophysicist	SOP 02-01 Checklist, Contractor QC Report (Attachment A)
Detection Survey	QAPP; SOP MR-AC-03-01; SOP MR-AC-06-01; SOP MR-SS-01-01	Detection survey has been completed according to SOP MR-AC-03-01, SOP MR-AC-06-01, and/or SOP MR-SS-01-01. QC and function tests conducted IAW SOP MR-AC-03-01, SOP MR-AC-06-01, and/or SOP MR-SS-01-01. If appropriate, CAs have been completed. Signatures and dates are present.	Lead Field Geophysicist	Contractor QC Report (Attachment A); Raw data files; MRSIMS Entries
Detection Survey Data Processing	QAPP; SOP MR-AC-04-01; SOP MR-SS-02-01	Detection survey data processing has been completed according to SOP MR-AC-04-01 and SOP MR-SS-02-01. Seed performance has been conducted. All specifications have been achieved, or exceptions noted. If appropriate, CAs have been completed. Signatures and dates are present.	QC Geophysicist	Contractor QC Report (Attachment A); Processed data files, processing and QC logs; Target lists; MRSIMS Entries

QAPP Worksheet #35: Data Verification and Validation Procedures (continued)

Activity and Records Reviewed	Requirements/ Specifications	Process Description/Frequency	Responsible Person	Documentation
Cued Survey	QAPP; SOP MR-AC-06-01	Cued survey has been completed according to SOP MR-AC-06-01. QC and function tests conducted IAW SOP MR-AC-06-01. If appropriate, CAs have been completed. Signatures and dates are present.	Lead Field Geophysicist	Contractor QC Report (Attachment A); Raw data files
Cued Survey Data Processing	QAPP; SOP MR-AC-07-01	Cued survey data processing has been completed according to SOP MR-AC-07-01. Preliminary prioritized dig list has been generated. Seed performance has been conducted. All specifications have been achieved, or exceptions noted. If appropriate, CAs have been completed. Signatures and dates are present.	QC Geophysicist	Contractor QC Report (Attachment A); Processed data files, processing and QC logs; Preliminary Prioritized Dig List

QAPP Worksheet #36: Geophysical Classification Process Validation

Validation of the AGC process is typically achieved through sets of calibration and validation digs. Because the purpose of using AGC for these RIs is to preferentially select TOI, to reduce the number of required digs, validation of the process will be achieved through assessment of the efficacy of using AGC to reduce the number of dig required to achieve the MC sampling objectives.

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QAPP Worksheet #37: Data Usability Assessment

This worksheet documents procedures that will be used to perform the data usability assessment. The data usability assessment will be performed as part of the project-specific report. It involves a qualitative and quantitative evaluation of the collected data to determine if the project data are of the right type, quality, and quantity to support the decisions that need to be made. It involves a retrospective review of the systematic planning process to evaluate whether underlying assumptions are supported, sources of uncertainty have been managed appropriately, data are representative of the population of interest, and the results can be used as intended, with the acceptable level of confidence.

Personnel responsible for participating in the data usability assessment preparation or review:

Name	Title	Organization	Role in Usability Assessment
Bill Hannah or future replacement	PM	CH2M	Reviewer
George DeMetropolis or future replacement	QC and H&S Program Manager	CH2M	Reviewer
Tamir Klaff or future replacement	Program Geophysicist	CH2M	Preparation
David Wright or future replacement	QC Geophysicist	CH2M	Preparation
George DeMetropolis or future replacement	H&S and QC Manager	CH2M	Preparation
Matthew Barner or future replacement	Project Geophysicist (Lead)	CH2M	Preparation
Jennifer Weller or future replacement	Data Processing Geophysicist	CH2M	Preparation

Documents used as input to the data usability assessment:

- QAPP
- Contract Specifications
- Final Validation Plan
- Weekly QC Reports
- CARs
- Production Area Seed Memorandum
- IVS Memoranda
- Site-Specific Munitions Classification Library
- Dynamic Data Analysis and Advanced Detection Target Selection Memorandum
- Prioritized Target “Dig” Lists (Preliminary and Final)
- Cued Data Analysis and Final Dig List Technical Memorandum

QAPP Worksheet #37: Data Usability Assessment (continued)

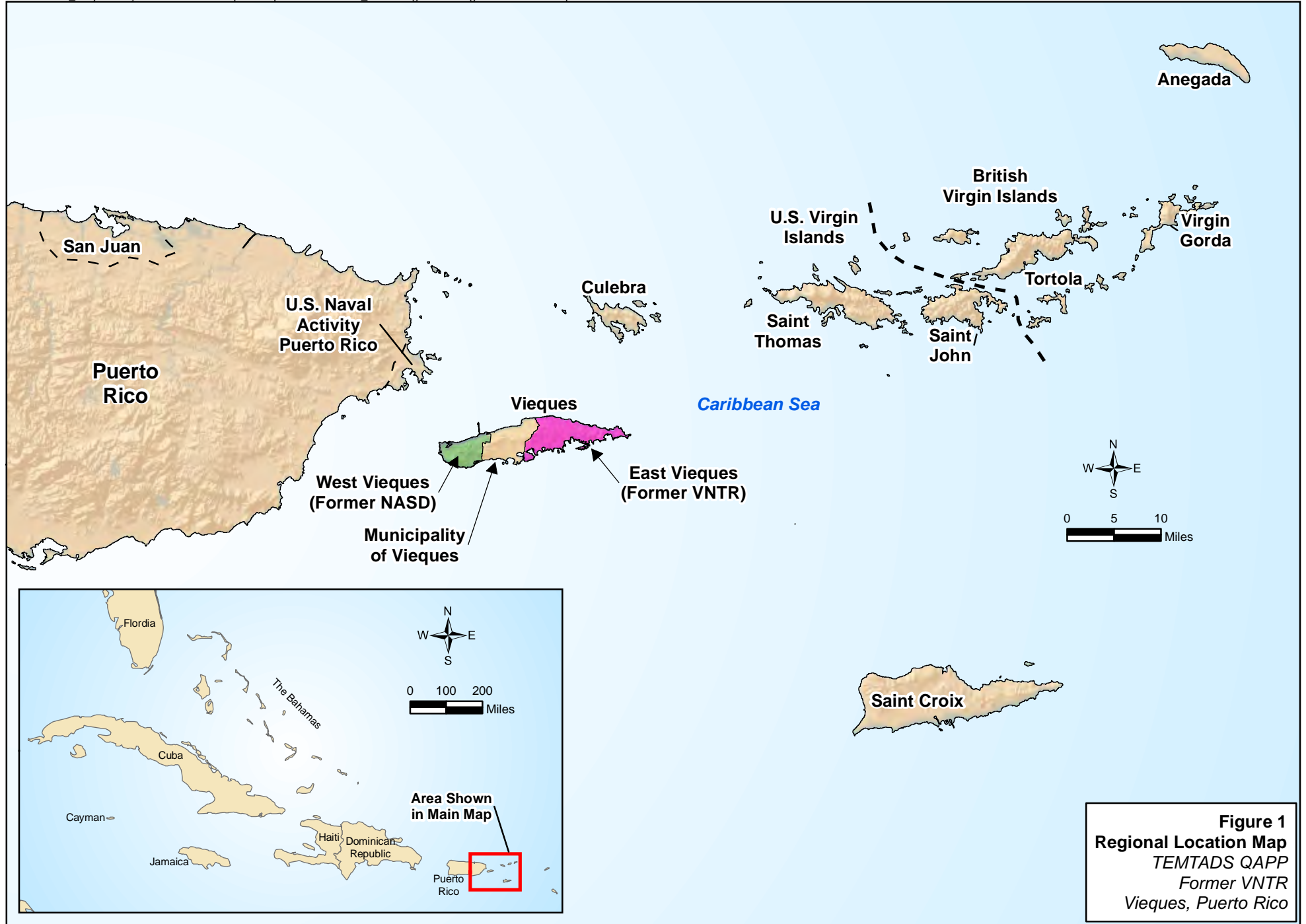
Data usability will be discussed in the project-specific report. The steps included in performing an assessment of the data usability will include the following:

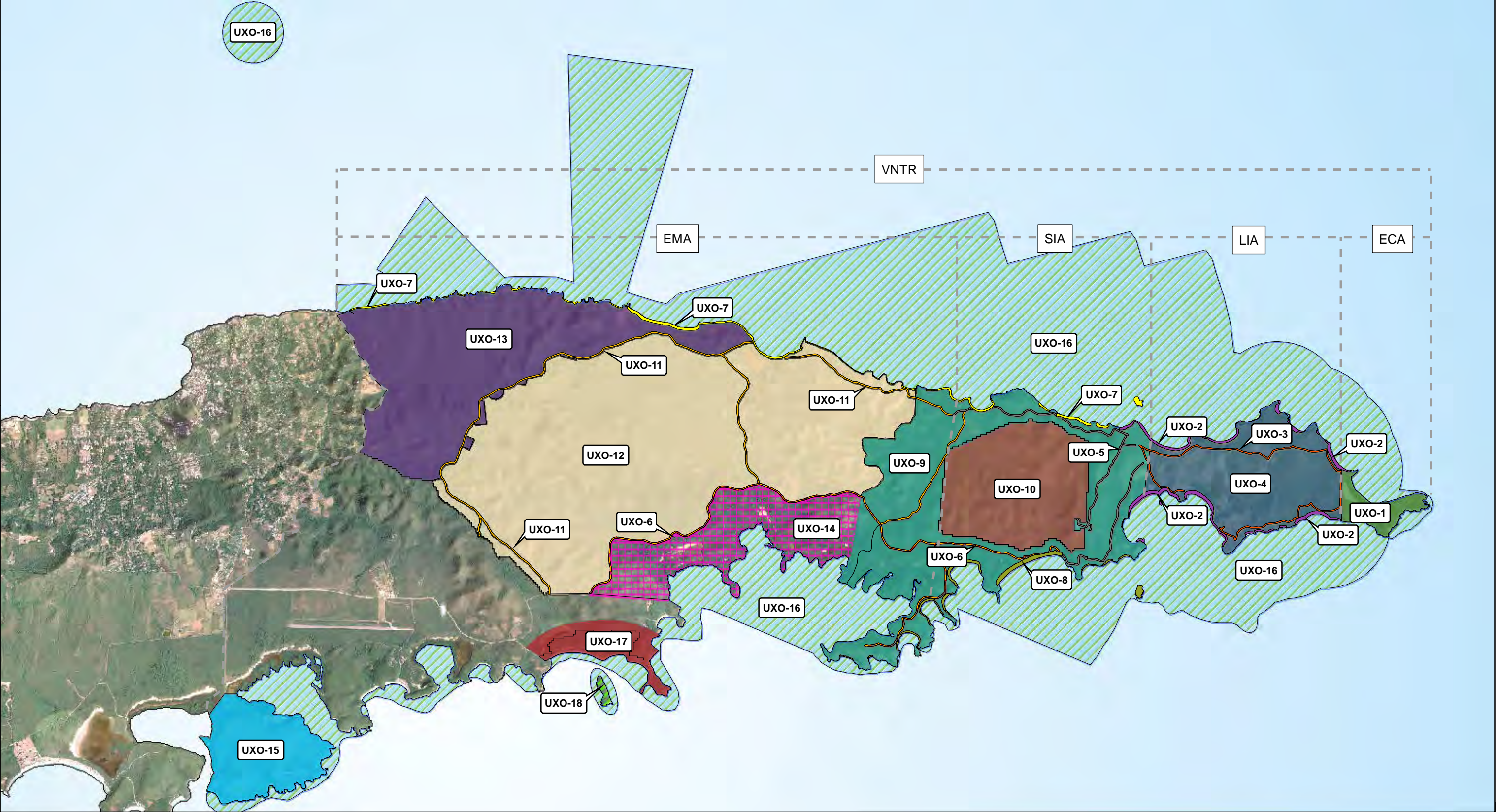
Step 1	Review the project's objectives and sampling design <i>Review the DQOs. Are underlying assumptions valid? Were the project boundaries appropriate? Review the sampling design as implemented for consistency with stated objectives. Were sources of uncertainty accounted for and appropriately managed? Summarize any deviations from the planned sample design.</i>
Step 2	Review the data verification/validation outputs and evaluate conformance to MPCs documented on Worksheet 12 <i>Review the site-specific project library for completeness. Review available QA/QC reports, including weekly QC reports, assessment reports, CARs, and the data validation report. Evaluate the implications of unacceptable QC results. Evaluate conformance to MPCs documented on Worksheet 12. Summarize the impacts of non-conformances on data usability.</i>
Step 3	Document data usability, update the CSM, and draw conclusions <i>Determine if the data can be used as intended, considering implications of deviations and CAs. Assess the performance of the sampling design and identify any limitations on data use. Update the CSM and document conclusions.</i>
Step 4	Document lessons learned and make recommendations <i>Summarize lessons learned and make recommendations for changes to DQOs or the sampling design for future similar studies. Prepare the data usability summary report.</i>

References

- Baker Environmental, Inc. (Baker). 1999. Results of the Hydrogeologic Investigation Vieques Island, Puerto Rico. November.
- CH2M HILL, Inc. (CH2M). 2000. *Live Impact Area Soil Sampling Report, U.S. Naval Facility Vieques Island, Puerto Rico*. October.
- CH2M. 2003. *Final Draft Preliminary Range Assessment Report, Vieques Naval Training Range, Vieques Island Puerto Rico*, April.
- CH2M. 2006. *Munitions and Explosives of Concern (MEC) Master Work Plan, Former Vieques Naval Training Range (VNTR), Vieques, Puerto Rico*. December.
- CH2M. 2007. *Revised Draft Expanded Range Assessment and Phase I Site Inspection Report, Former Vieques Naval Training Range (VNTR), Vieques, Puerto Rico*. May.
- CH2M. 2008a. *Preliminary Assessment/Site Inspection Report, 12 Consent Order Sites and 8 PI/PAOC Sites, Former Vieques Naval Training Range, Vieques, Puerto Rico*. June.
- CH2M. 2008b. *Work Plan for Munitions and Explosives of Concern, Subsurface Interim Removal Action, Beaches and Select Roadways, Former Vieques Naval Training Range and Former NASD Solid Waste Management Unit 4, Vieques, Puerto Rico*. October.
- CH2M. 2009. *Non-Time Critical Removal Action Work Plan, Surface Munitions and Explosives of Concern at Munitions Response Area-Surface Impact Area, Munitions Response Sites 1 through 7, former VNTR, Vieques, Puerto Rico*. January.
- CH2M. 2010a. *Expanded Range Assessment/Site Inspection Report, Former Vieques Naval Training Range, Vieques, Puerto Rico*. September.
- CH2M. 2010b. *Status Report, Time Critical Removal Action, Interim Action For the Removal of Surface Munitions and Explosives of Concern at Munitions Response Areas-Live Impact Area, and Eastern Conservation Area, Former Vieques Naval Training Range (VNTR), Vieques, Puerto Rico*. October.
- CH2M. 2013. *Master Sampling and Analysis Plan East Vieques Terrestrial UXO Sites, Former Vieques Naval Training Range, Vieques, Puerto Rico*. January.
- CH2M. 2015. *Site Management Plan Fiscal Year 2016, Atlantic Fleet Weapons Training Area – Vieques, Vieques, Puerto Rico*. November.
- CH2M. 2016. *Addendum 4, Master Sampling and Analysis Plan, UXOs 3, 5, 6, and 11 Remedial Investigation, Atlantic Fleet Weapons Training Area – Vieques, Former Vieques Naval Training Range, Vieques, Puerto Rico*. January.
- Department of the Interior (DOI). 2007. *Vieques National Wildlife Refuge Comprehensive Plan and Environmental Impact Statement*. August.
- Naval Facilities Engineering Command (NAVFAC). 2003. *Draft Final Environmental Baseline Survey, Vieques Naval Training Range, Vieques Island, Puerto Rico*. April.
- United States Army Corps of Engineers (USACE). 2008. *Explosives Safety and Health Requirements Manual, Department of the Army, Washington, DC*. September.

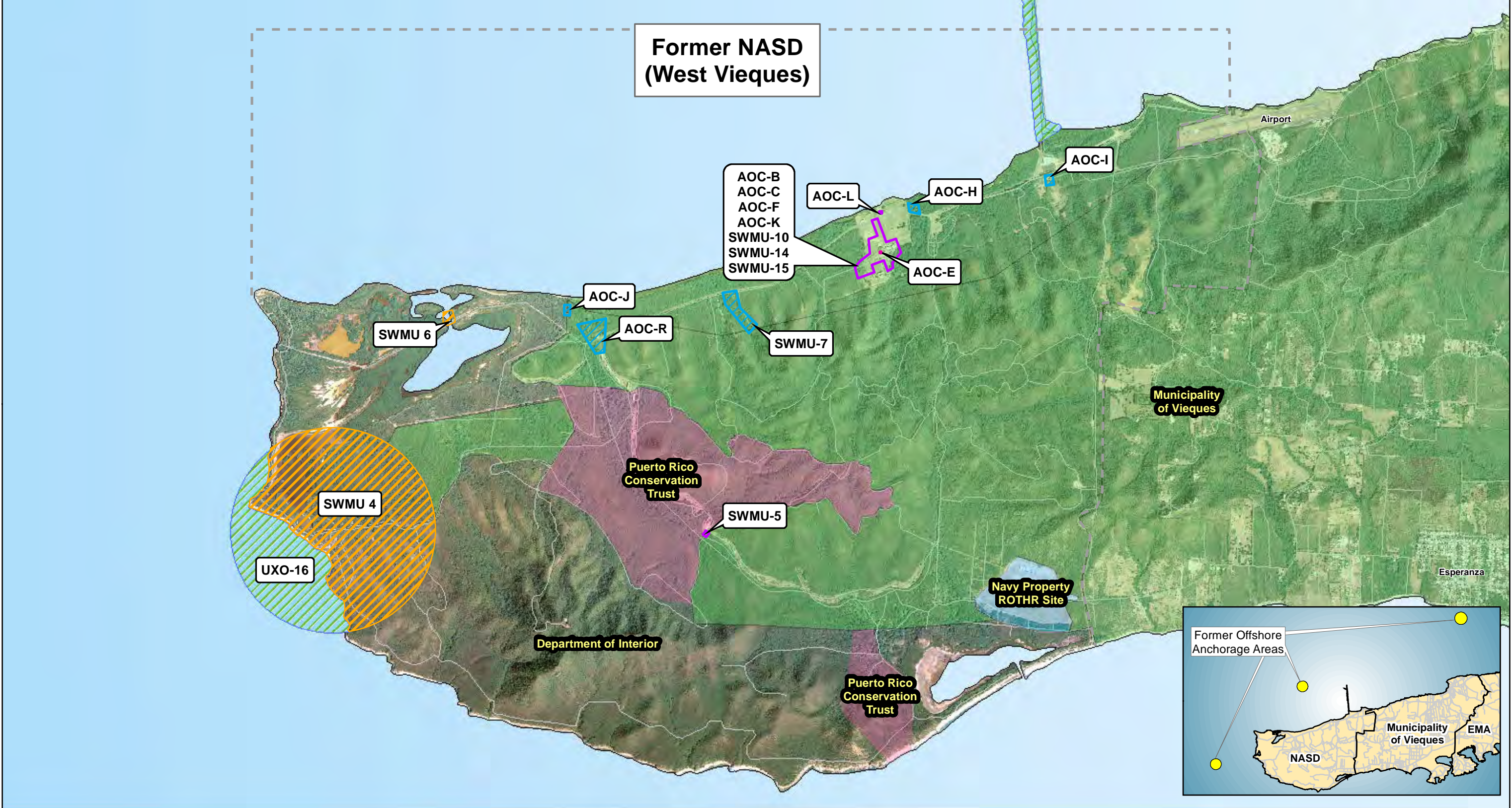
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- Legend**
- Munitions Response Sites**
- UXO 1 - ECA
 - UXO 2 - LIA Beaches
 - UXO 3 - LIA Roads
 - UXO 4 - LIA Interior
 - UXO 5 - SIA Restricted Roads
 - UXO 6 - EMA/SIA Public Roads
 - UXO 7 - EMA/SIA North Beaches
 - UXO 8 - SIA South Beaches
 - UXO 9 - SIA Exterior
 - UXO 10 - SIA Interior
 - UXO 11 - EMA Public Roads
 - UXO 12 - EMA Interior
 - UXO 13 - EMA West
 - UXO 14 - EMA South
 - UXO 15 - Puerto Ferro
 - UXO 16 - Underwater Areas
 - UXO 17 - Other Sites (PAOC EE)
 - UXO 18 - Cayo de la Chiva

Figure 2
East Vieques Munitions Response Sites
TEM TADS QAPP
Former VNTR
Vieques, Puerto Rico



Legend

- | | | |
|--------------------------------------|-------------------------------|--------------------------------|
| Remedial Action | Vieques Land Ownership | Munitions Response Site |
| No Further Action Record of Decision | Department of Interior | UXO 16 -Underwater Areas |
| No Further Action Decision Document | Municipality of Vieques | Vieques Features |
| Feasibility Study Addendum | Navy Property - ROTH Site | Road |
| | PR Conservation Trust | |

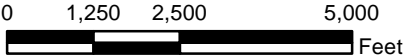


Figure 4
West Vieques Sites
TEMTADS QAPP
Former VNTR
Vieques, Puerto Rico

Attachment A
Quality Control Forms

FORM 6-9

FIELD CHANGE REQUEST

PROJECT ID _____ PROJECT # _____ FIELD CHANGE # _____

TO _____ DEPT. _____ LOCATION _____ DATE _____

RE: ☐ WP Section. _____ TITLE _____

☐ DFW NO. _____ TITLE _____

☐ OTHER _____

1. DESCRIPTION (Items involved, submit map if applicable) _____

2. REASONS FOR CHANGE:

3. RECOMMENDED DISPOSITION ☐ MINOR CHANGE ☐ MAJOR CHANGE

4. SUXOS/MEC Manager (Signature) DATE UXOQCS CONCURRENCE (Signature) DATE

5. DISPOSITION

☐ NOT APPROVED (Give Reason)

☐ CONSIDERED MINOR CHANGE – Approved per Recommended Disposition

☐ CONSIDERED MAJOR CHANGE – Action will be taken upon Project Manager authorization

SUXOS signs and returns to UXOQCS for transmittal to Project Manager with copies to:

Project QC Manager _____ Others as Required _____

Procurement Officer _____

Project Files _____

FORM 6-10

CORRECTIVE ACTION REQUEST

⁽¹⁾Page 1 of 2

⁽²⁾ CAR #:	⁽³⁾ PRIORITY: <input type="checkbox"/> HIGH <input type="checkbox"/> NORMAL	⁽⁴⁾ DATE PREPARED:
-----------------------	--	-------------------------------

PART A: NOTICE OF DEFICIENCY

⁽⁵⁾ PROJECT:		
⁽⁶⁾ PROJECT MANAGER:	⁽⁷⁾ QC MANAGER/STAFF:	
⁽⁸⁾ CONSTRUCTION MANAGER:	⁽⁹⁾ MEC MANAGER:	
⁽¹⁰⁾ ISSUED TO (INDIVIDUAL & ORGANIZATION):		
⁽¹¹⁾ REQUIREMENT & REFERENCE:		
⁽¹²⁾ PROBLEM DESCRIPTION & LOCATION:		
⁽¹³⁾ CAP REQUIRED? <input type="checkbox"/> YES <input type="checkbox"/> NO		⁽¹⁴⁾ RESPONSE DUE:
⁽¹⁵⁾ ISSUED BY (PRINTED NAME & TITLE):		⁽¹⁶⁾ MANAGEMENT CONCURRENCE:
SIGNATURE:	DATE:	

PART B: CORRECTIVE ACTION

⁽¹⁷⁾ PROPOSED CORRECTIVE ACTION/ACTION TAKEN:	
NOTE: SUPPORTING DOCUMENTATION MUST BE LISTED ON THE BACK OF THIS FORM AND ATTACHED.	
⁽¹⁸⁾ PART B COMPLETED BY (NAME & TITLE):	⁽¹⁹⁾ QC CONCURRENCE:
SIGNATURE:	DATE:

PART C: CORRECTIVE ACTION VERIFICATION

⁽²⁰⁾ CAR VERIFICATION AND CLOSE-OUT: (CHECK ONLY ONE & EXPLAIN STIPULATIONS, IF ANY)
<input type="checkbox"/> APPROVED FOR CLOSURE WITHOUT STIPULATIONS <input type="checkbox"/> APPROVED FOR CLOSURE WITH FOLLOWING STIPULATIONS
COMMENTS/STIPULATIONS:
⁽²¹⁾ CLOSED BY (PRINTED NAME & TITLE):
SIGNATURE: DATE:

CORRECTIVE ACTION REQUEST (CAR) INSTRUCTION SHEET

Page 2 of 2

- (1) QC Manager: Verify that the total number of pages includes all attachments.
- (2) QC Manager: Fill in CAR number from CAR log.
- (3) CQC System Manager: Fill in appropriate priority category. High priority indicates resolution of deficiency requires expediting corrective action plan and correction of deficient conditions noted in the CAR and extraordinary resources may be required due to the deficiency's impact on continuing operations. Normal priority indicates that the deficiency resolution process may be accomplished without further impacting continuing operations.
- (4) CAR Requestor: Fill in date CAR is initiated.
- (5) CAR Requestor: Identify project name, number, CTO, and WAD.
- (6) CAR Requestor: Identify Project Manager
- (7) CAR Requestor: Identify CQC System Manager.
- (8) CAR Requestor: Identify project organization, group, or discrete work environment where deficiency was first discovered.
- (9) CAR Requestor: Identify line manager responsible for work unit where deficiency was discovered.
- (10) QC Manager: Identify responsible manager designated to resolve deficiency (this may not be work unit manager).
- (11) CAR Requestor: Identify source of requirement violated in contract, work planning document, procedure, instruction, etc; use exact reference to page and, when applicable, paragraph.
- (12) CAR Requestor: Identify problem as it relates to requirement previously stated. Identify location of work activities impacted by deficiency.
- (13) QC Manager: Identify if Corrective Action Plan (CAP) is required. CAP is typically required where one or more of the following conditions apply: CAR priority is High; deficiency requires a rigorous corrective action planning process to identify similar work product or activities affected by the deficiency; or deficiency requires extensive resources and planning to correct the deficiency and to prevent future recurrence.
- (14) QC Manager: Identify date by which proposed corrective action is due to QC for concurrence.
- (15) QC Manager: Sign and date CAR and forward to responsible manager identified in (10) above.
- (16) Responsible Manager: Initial to acknowledge receipt of CAR.
- (17) Responsible Manager: Complete corrective action plan and identify date of correction. Typical corrective action response will include statement regarding how the condition occurred, what the extent of the problem is (if not readily apparent by the problem description statement in [12]), methods to be used to correct the condition, and actions to be taken to prevent the condition from recurring. If a CAP is required, refer to CAP only in this section.
- (18) Responsible Manager: Sign and date corrective action response.
- (19) QC Manager: Initial to identify concurrence with corrective action response from responsible manager.
- (20) QC Manager: Check appropriate block to identify if corrective action process is complete so that CAR may be closed. Add close-out comments relevant to block checked.
- (21) QC Manager: Indicate document closeout by signing and dating.

FORM 6-11**CORRECTIVE ACTION PLAN**

Page 1 of 1

*Attach clarifications and additional information as needed. Identify attached material in appropriate section of this form.***PART A: TO BE COMPLETED BY PROJECT MANAGER OR DESIGNEE**

(1)PROJECT:		
(2)PROJECT MANAGER:	(3)QC MANAGER:	
(4)CAR NO(S) AND DATE(S) ISSUED:		
(5)DEFICIENCY DESCRIPTION AND LOCATION:		
(6)PLANNED ACTIONS	(7)ASSIGNED RESPONSIBILITY	(8) COMPLETION DUE DATE
(9)PROJECT MANAGER SIGNATURE:		

PART B: TO BE COMPLETED BY CQC SYSTEM MANAGER OR DESIGNEE

(10)CAP REVIEWED BY:	DATE:
(11)REVIEWER COMMENTS:	
(12)CAP DISPOSITION: (CHECK ONLY ONE AND EXPLAIN STIPULATIONS, IF ANY) <input type="checkbox"/> APPROVED WITHOUT STIPULATIONS <input type="checkbox"/> APPROVED WITH STIPULATIONS <input type="checkbox"/> APPROVAL DELAYED, FURTHER PLANNING REQUIRED COMMENTS:	
(13)QC MANAGER SIGNATURE:	

Root Cause Analysis Form

Form 6-12

Root Cause Analysis (RCA)

Root Cause Categories (RCC): Select the RCC numbered below that applies for the root cause (RC) and/or contributing factor (CF) in the first column, then describe the specific root cause and corrective actions in each column.

1. Lack of skill or knowledge
2. Lack of or inadequate operational procedures or work standards
3. Inadequate communication of expectations regarding procedures or work standards
4. Inadequate tools or equipment
5. Correct way takes more time and/or requires more effort
6. Short-cutting standard procedures is positively reinforced or tolerated
7. Person thinks there is no personal benefit to always doing the job according to standards

RCC #	Root Cause(s)	Corrective Actions	RC ¹	CF ²	Due Date	Date Completed	Date Verified

¹ RC = Root Cause; ² CF = Contributing Factors (check which applies)

Investigation Team Members

Name	Job Title	Date

Results of Solution Verification and Validation

Reviewed By

Name	Job Title	Date

Determination of Root Cause(s)

For minor losses or near losses the information may be gathered by the supervisor or other personnel immediately following the loss. Based on the complexity of the situation, this information may be all that is necessary to enable the investigation team to analyze the loss, to determine the root cause, and to develop recommendations. More complex situations may require the investigation team to revisit the loss site or re-interview key witnesses to obtain answers to questions that may arise during the investigation process.

Photographs or videotapes of the scene and damaged equipment should be taken from all sides and from various distances. This point is especially important when the investigation team will not be able to review the loss scene.

The investigation team must use the Root Cause Analysis Flow Chart to assist in identifying the root cause(s) of a loss. Any loss may have one or more “root causes” and “contributing factors”. The “root cause” is the primary or immediate cause of the incident, while a “contributing factor” is a condition or event that contributes to the incident happening, but is not the primary cause of the incident. Root causes and contributing factors that relate to the *person* involved in the loss, his or her peers, or the supervisor should be referred to as “personal factors”. Causes that pertain to the *system* within which the loss or injury occurred should be referred to as “job factors”.

Personal Factors

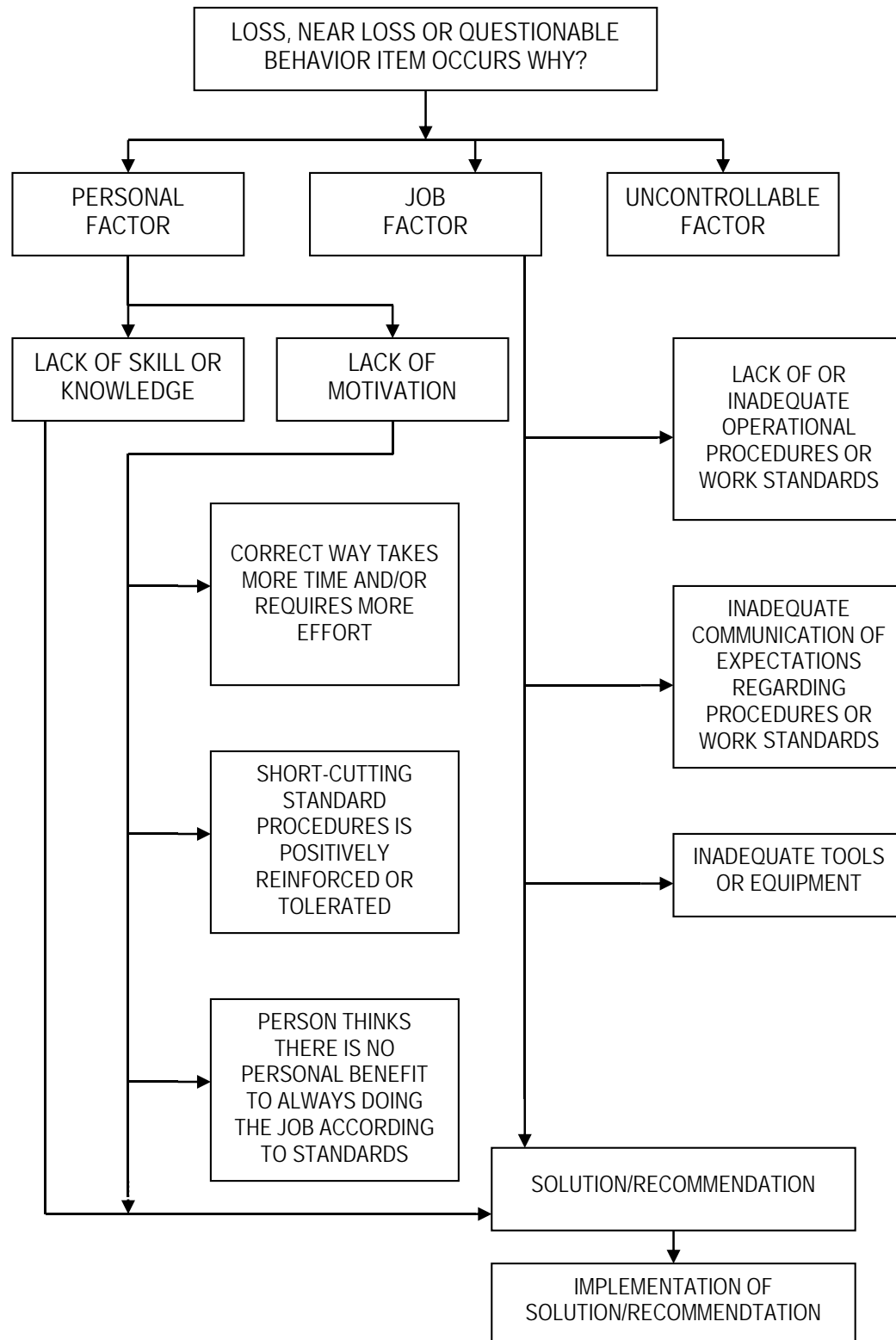
- Lack of skill or knowledge
- Correct way takes more time and/or requires more effort
- Short-cutting standard procedures is positively reinforced or tolerated
- Person thinks that there is no personal benefit to always doing the job according to standards

Job Factors

- Lack of or inadequate operational procedures or work standards.
- Inadequate communication of expectations regarding procedures or standards
- Inadequate tools or equipment

The root cause(s) could be any one or a combination of these seven possibilities or some other “uncontrollable factor”. In the vast majority of losses, the root cause is very much related to one or more of these seven factors. Uncontrollable factors should be used rarely and only after a thorough review eliminates “all” seven other factors.

Root Cause Analysis Flow Chart



CONTRACTOR PRODUCTION REPORT (ATTACH ADDITIONAL SHEETS IF NECESSARY)		DATE OF REPORT: REVISION NO: REVISION DATE:			
CTO NO:	PROJECT NAME/LOCATION:		REPORT NO:		
PROJECT NO:	SUPERINTENDENT:	SITE H&S SPECIALIST:			
AM WEATHER:	PM WEATHER:	MAX TEMP: F	MIN TEMP: F		
SUMMARY OF WORK PERFORMED TODAY					
<div style="border: 2px solid black; border-radius: 50%; padding: 10px; width: 80px; margin: 0 auto;"> JOB SAFETY </div>	Was A Job Safety Meeting Held This Date? <input type="checkbox"/> Yes <input type="checkbox"/> No		TOTAL WORK HOURS ON JOB SITE THIS DATE (Including Continuation Sheets)		
	Were there any lost-time accidents this date? (If Yes, attach copy of completed OSHA report) <input type="checkbox"/> Yes <input type="checkbox"/> No		CH2MHILL On-Site Hours		
	Was a Confined Space Entry Permit Administered This Date? (If Yes, attach copy of each permit) <input type="checkbox"/> Yes <input type="checkbox"/> No		AGVIQ On-Site Hours		
	Was Crane/Manlift/Trenching/Scaffold/HV Elec/High Work/Hazmat Work Done?? (If Yes, attach statement or checklist showing inspection performed) <input type="checkbox"/> Yes <input type="checkbox"/> No		Subcontractor On-Site Hours		
			Total On-Site Hours This Date		
	Was Hazardous Material/Waste Released into the Environment? (If Yes, attach description of incident and proposed action) <input type="checkbox"/> Yes <input type="checkbox"/> No		Cumulative Total of Work Hours From Previous Report		
Total Work Hours From Start of Construction					
SAFETY ACTIONS TAKEN TODAY/SAFETY INSPECTIONS CONDUCTED (Include Safety Violations, Corrective Instructions Given, Corrective Actions Taken, and Results of Safety Inspections Conducted):					
EQUIPMENT/MATERIAL RECEIVED TODAY TO BE INCORPORATED IN JOB					
DESCRIPTION OF EQUIPMENT/MATERIAL RECEIVED	MAKE/ MODEL/ MANUFACTURER	EQUIPMENT/ LOT NUMBER	INSPECTION PERFORMED BY		
EQUIPMENT USED ON JOB SITE TODAY.					
EQUIPMENT DESCRIPTION	EQUIPMENT MAKE/MODEL	SAFETY CHECK PERFORMED BY	NUMBER OF HOURS		
			USED	IDLE	REPAIR
CHANGED CONDITIONS/DELAY/CONFLICTS ENCOUNTERED (List any conflicts with the delivery order [i.e., scope of work and/or drawings], delays to the project attributable to site and weather conditions, etc.):					
VISITORS TO THE SITE:					
LIST OF ATTACHMENTS (OSHA report, confined space entry permit, incident reports, etc.):					
SAFETY REQUIREMENTS HAVE BEEN MET <input type="checkbox"/>					
_____ SUPERINTENDENT'S SIGNATURE				_____ DATE	

		CONTRACTOR QUALITY CONTROL REPORT (ATTACH ADDITIONAL SHEETS IF NECESSARY)		REPORT DATE:
CTO NO:		PROJECT NAME/LOCATION:		REVISION NO:
PROJECT NO:		PROJECT QC MANAGER:	SITE H&S SPECIALIST:	
REVISION DATE:				
REPORT NO:				
SAFETY MEETINGS AND INSPECTIONS				
WAS A SAFETY MEETING HELD THIS DAY?		<input type="checkbox"/> YES <input type="checkbox"/> NO	IF YES, ATTACH SAFETY MEETING MINUTES	
WAS CRANE USED ON THE SITE THIS DAY?		<input type="checkbox"/> YES <input type="checkbox"/> NO	IF YES, ATTACH DAILY CRANE REPORT OF INSPECTION AND CONTRACTOR CRANE OPERATION CHECKLIST	
DEFINABLE FEATURES OF WORK STATUS				
DFOW No.	Definable Feature Of Work		Preparatory	Initial
1			<input type="checkbox"/>	<input type="checkbox"/>
2			<input type="checkbox"/>	<input type="checkbox"/>
3			<input type="checkbox"/>	<input type="checkbox"/>
4			<input type="checkbox"/>	<input type="checkbox"/>
5			<input type="checkbox"/>	<input type="checkbox"/>
6			<input type="checkbox"/>	<input type="checkbox"/>
7			<input type="checkbox"/>	<input type="checkbox"/>
8			<input type="checkbox"/>	<input type="checkbox"/>
9			<input type="checkbox"/>	<input type="checkbox"/>
10			<input type="checkbox"/>	<input type="checkbox"/>
11			<input type="checkbox"/>	<input type="checkbox"/>
12			<input type="checkbox"/>	<input type="checkbox"/>
13			<input type="checkbox"/>	<input type="checkbox"/>
14			<input type="checkbox"/>	<input type="checkbox"/>
15			<input type="checkbox"/>	<input type="checkbox"/>
PREPARATORY	WAS PREPARATORY PHASE WORK PERFORMED TODAY? <input type="checkbox"/> YES <input type="checkbox"/> NO			
	IF YES, FILL OUT AND ATTACH SUPPLEMENTAL PREPARATORY PHASE CHECKLIST.			
	DFOW No.(from list above).	TASK/ACTIVITY		PREPARATORY PHASE REPORT NO.
INITIAL AND FOLLOW-UP FEATURE OF WORK COMMENTS				
DFOW No.(from list above)	Phase	Comment/Finding/Action		
	Initial <input type="checkbox"/> Follow up <input type="checkbox"/>			
	Initial <input type="checkbox"/> Follow up <input type="checkbox"/>			
	Initial <input type="checkbox"/> Follow up <input type="checkbox"/>			
	Initial <input type="checkbox"/> Follow up <input type="checkbox"/>			
	Initial <input type="checkbox"/> Follow up <input type="checkbox"/>			
	Initial <input type="checkbox"/> Follow up <input type="checkbox"/>			
	Initial <input type="checkbox"/> Follow up <input type="checkbox"/>			
	Initial <input type="checkbox"/> Follow up <input type="checkbox"/>			
	Initial <input type="checkbox"/> Follow up <input type="checkbox"/>			
REWORK ITEMS IDENTIFIED TODAY (NOT CORRECTED BY CLOSE OF BUSINESS)		REWORK ITEMS CORRECTED TODAY (FROM REWORK ITEMS LIST)		
TASK/ACTIVITY	DATE ISSUED	DESCRIPTION	TASK/ACTIVITY	CORRECTIVE ACTION(S) TAKEN

		CONTRACTOR QUALITY CONTROL REPORT (ATTACH ADDITIONAL SHEETS IF NECESSARY)				REPORT DATE: REVISION NO: REVISION DATE:	
CTO NO:		PROJECT NAME/LOCATION:				REPORT NO:	
PROJECT NO:		PROJECT QC MANAGER:			SITE H&S SPECIALIST:		
SAMPLING/TESTING PERFORMED							
SAMPLING/TESTING PERFORMED				SAMPLING/TESTING COMPANY		SAMPLING/TESTING PERSONNEL	
MATERIALS/EQUIPMENT INSPECTION (Materials received and inspected against specifications)							
MATERIAL/EQUIPMENT DESCRIPTION			SPECIFICATION		MATERIAL ACCEPTED?		COMMENT/REASON/ACTION
					YES <input type="checkbox"/> NO <input type="checkbox"/>		
					YES <input type="checkbox"/> NO <input type="checkbox"/>		
					YES <input type="checkbox"/> NO <input type="checkbox"/>		
					YES <input type="checkbox"/> NO <input type="checkbox"/>		
					YES <input type="checkbox"/> NO <input type="checkbox"/>		
					YES <input type="checkbox"/> NO <input type="checkbox"/>		
					YES <input type="checkbox"/> NO <input type="checkbox"/>		
SUBMITTALS INSPECTION / REVIEW							
SUBMITTAL NO	SUBMITTAL DESCRIPTION		SPEC/PLAN REFERENCE		SUBMITTAL APPROVED?		COMMENT/REASON/ACTION
					YES <input type="checkbox"/> NO <input type="checkbox"/>		
					YES <input type="checkbox"/> NO <input type="checkbox"/>		
					YES <input type="checkbox"/> NO <input type="checkbox"/>		
					YES <input type="checkbox"/> NO <input type="checkbox"/>		
OFF-SITE SURVEILLANCE ACTIVITIES, INCLUDING ACTIONS TAKEN:							
ACCUMULATION/STOCKPILE AREA INSPECTION							
INSPECTION PERFORMED BY:				SIGNATURE OF INSPECTOR:			
ACCUMULATION/ STOCKPILE AREA LOCATION							
NO OF CONTAINERS:			NO OF TANKS:			NO OF ROLL-OFF BOXES:	
						NO OF DRUMS:	
INSPECTION RESULTS:							
TRANSPORTATION AND DISPOSAL ACTIVITIES/SUMMARY/QUANTITIES:							
GENERAL COMMENTS (rework, directives, etc.):							
LIST OF ATTACHMENTS (examples, as applicable: preparatory phase checklist, QC meeting minutes, safety meeting minutes, crane inspections, crane operation checklist, COCs, weight tickets, manifests, profiles, rework item list, testing plan and log, etc.):							
<i>On behalf of the contractor, I certify that this report is complete and correct and equipment and material used and work performed during this reporting period is in compliance with the contract drawings and specifications to the best of my knowledge except as noted in this report.</i>							
						PROJECT QC MANAGER'S SIGNATURE	
						DATE	
<i>On behalf of the contractor, I attest that the work for which payment is requested, including stored material, is in compliance with contract requirements.</i>							
						PROJECT QC MANAGER'S SIGNATURE	
						DATE	

		PREPARATORY PHASE REPORT		REPORT NO:	REPORT DATE:
				REVISION NO:	REVISION DATE:
PROJECT NO:		DEFINABLE FEATURE OF WORK:		SITE/ACTIVITY:	
PERSONNEL PRESENT					
	NAME		POSITION		COMPANY/GOVERNMENT
SUBMITTALS	REVIEW SUBMITTALS AND/OR SUBMITTAL REGISTER.		HAVE ALL SUBMITTALS BEEN APPROVED? YES <input type="checkbox"/> NO <input type="checkbox"/>		
	IF NO, WHAT ITEMS HAVE NOT BEEN SUBMITTED?				
	ARE ALL MATERIALS ON HAND? YES <input type="checkbox"/> NO <input type="checkbox"/>				
	IF NO, WHAT ITEMS ARE MISSING?				
MATERIAL STORAGE	ARE MATERIALS STORED PROPERLY? YES <input type="checkbox"/> NO <input type="checkbox"/>				
	IF NO, WHAT ACTION IS TAKEN?				
SPECIFICATIONS	REVIEW EACH PARAGRAPH OF SPECIFICATIONS.				
	DISCUSS PROCEDURE FOR ACCOMPLISHING THE WORK.				
PRELIM WORK & PERMITS	ENSURE PRELIMINARY WORK IS CORRECT AND PERMITS ARE ON FILE.				
	IF NO, WHAT ACTION IS TAKEN?				

		PREPARATORY PHASE REPORT		REPORT NO:	REPORT DATE:
				REVISION NO:	REVISION DATE:
PROJECT NO:		DEFINABLE FEATURE OF WORK:		SITE/ACTIVITY:	
TESTING	IDENTIFY TEST TO BE PERFORMED, FREQUENCY, AND BY WHOM.				
	TEST		FREQUENCY		PERFORMER
	WHEN REQUIRED?				
	WHERE REQUIRED?				
	REVIEW TESTING PLAN.				
	HAVE TEST FACILITIES BEEN APPROVED?				
	TEST FACILITY			APPROVED?	
			YES <input type="checkbox"/> NO <input type="checkbox"/>		
			YES <input type="checkbox"/> NO <input type="checkbox"/>		
SAFETY	ACTIVITY HAZARD ANALYSIS APPROVED? YES <input type="checkbox"/> NO <input type="checkbox"/>				
	REVIEW APPLICABLE PORTION OF EM 385-1-1 AND AHA.				
MEETING COMMENTS	NAVY/ROICC COMMENTS DURING MEETING.				
OTHER ITEMS OR REMARKS	OTHER ITEMS OR REMARKS:				
QC REPRESENTATIVE'S NAME		QC REPRESENTATIVE'S SIGNATURE			DATE

Attachment B
Standard Operating Procedures

Standard Operating Procedures List

SOP	Title
MR-AC-01-01	Assemble the TEMTADS System for Dynamic Collection and Verify Operation (CH2M)
MR-AC-02-01	Perform Initial Dynamic Instrument Verification Strip (IVS) Survey – TEMTADS 2x2 (CH2M)
MR-AC-03-01	Perform Dynamic Surveys with TEMTADS 2x2 (CH2M)
MR-AC-04-01	Process Dynamic Survey Data - TEMTADS 2x2 (CH2M)
MR-AC-05-01	Perform Initial Cued Instrument Verification Strip (IVS) Survey – TEMTADS 2x2 (CH2M)
MR-AC-06-01	Perform Cued Surveys with TEMTADS 2x2 (CH2M)
MR-AC-07-01	Process Cued Surveys with TEMTADS 2x2 (CH2M)
MR-AC-08-01	Reacquisition of Targets Prior to Intrusive Investigations (CH2M)
MR-AC-20-01	Surface Sweep Quality Control Seeding (CH2M)
MR-AC-21-01	Production Area Quality Control Seeding (CH2M)
MR-AC-22-01	Surface Clearance (CH2M)
MR-SS-01-01	EM61-MK2 Field Procedures for Munitions Response (CH2M)
MR-SS-02-01	Process Standard Sensor Data for Munitions Response (CH2M)
MR-SS-02-02	Quality Control of Standard Sensor DGM Data (CH2M)
TBD SOP-01	Explosive Demolition & Demilitarization Operations (to be provided by MEC subcontractor)
TBD SOP-02	Material Potentially Presenting an Explosive Hazard (MPPEH) Processing and Management (to be provided by MEC subcontractor)
TBD SOP-03	Anomaly Investigation (to be provided by MEC subcontractor)

Assemble the TEMTADS 2x2 System for Dynamic Collection and Verify Operation

1 Purpose

The purpose of this SOP is to identify the methods to be employed when assembling the TEMTADS 2x2 sensor system for dynamic collection and verifying that all components are correctly assembled, operating normally, and are capable of acquiring data of sufficient quality.

2 Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP. The following is a list of required equipment and materials:

- TEMTADS 2x2 sensor coupled with a real-time kinematic Global Positioning System (RTK GPS) and Inertial Measurement Unit (IMU) for orientation measurements
- A schedule 80 small Industry Standard Object (small ISO80) in the Delrin mounting ring for sensor function testing
- Digital camera

2.1 Personnel and Qualification

The following individuals will be involved in the assembly verification of the TEMTADS:

- Project Geophysicist
- Field Geophysicist
- Data Processor
- Quality Control (QC) Geophysicist

The qualifications of the personnel implementing this SOP are documented in the Uniform Federal Policy (UFP) Quality Assurance Project Plan, Geophysical Classification for Munitions Response (GCMR QAPP), Worksheet #7.

3 Procedures and Guidelines

The TEMTADS 2x2 is an advanced electromagnetic induction sensor designed for the detection and classification of buried metal objects. The sensor consists of four sensor elements arranged on 40-centimeter (cm) centers in a 2x2 array. Each sensor element consists of a 35-cm square transmit coil for target illumination with an 8-cm three-axis receive cube centered in the transmit coil. The transmitters are energized in sequence and the decay curve is recoded up to 25 milliseconds after the transmitters are turned off for each of the 12 (4 cubes with 3 axes each) receive channels. A schematic of the sensor coil configuration is shown on Figure 1.

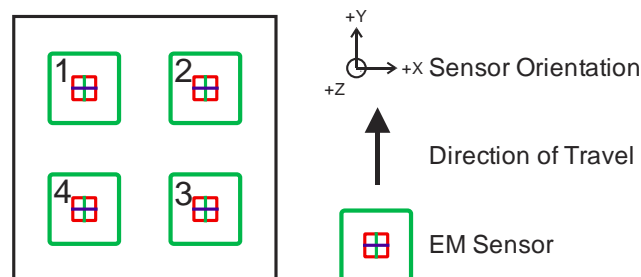
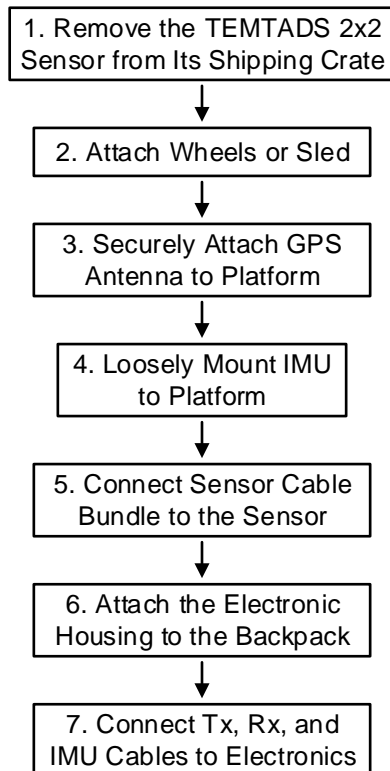


Figure 1. Orientation of the Four TEMTADS 2x2 Sensor Elements

Positioning of the TEMTADS 2x2 is accomplished using an RTK GPS. The TEMTADS 2x2 orientation is measured using a six-degree-of-freedom IMU. For proper functioning it is important to verify that the IMU has been mounted to the TEMTADS 2x2 in the correct orientation.

3.1 Assemble the TEMTADS 2x2

Figure 2. Overview of the TEMTADS Assembly Process



All assembly operations are described in the TEMTADS 2x2 unpacking instructions and user guide available from the Naval Research Laboratory (NRL) and the detailed instructions contained there should be followed precisely. Figure 2 shows a schematic overview of the assembly steps which are briefly described below:

1. Remove the sensor assembly from the packing crate following the instructions in the unpacking guide.
2. Attach the wheels or sled.
3. Securely attach the GPS antenna to the top of the mounting platform. If GPS is not being used, move to Step 4.
4. Set the IMU onto its position below the GPS. The attachment will be secured after correct IMU orientation is verified.
5. Connect the sensor cable bundle to the sensor. This includes the sensor TX and RX cables and the cables to the GPS and IMU.
6. Remove the electronic housing from its shipping container and attach it to the backpack.
7. Attach the Tx, Rx, and IMU cables to the electronics box. The GPS cable will be attached after booting the computer.

3.2 Turn On and Initialize the Data Acquisition Computers

Following the instructions in Section 5 of the TEMTADS 2x2 Users Guide, start the data acquisition system. After the main computer in the electronics housing boots, plug the GPS cable into the electronics. If GPS cable was attached prior to the full boot of the main computer, turn the system off, unplug the GPS cable and reboot main computer. The last step in Section 5 involves observing the IMU output. Leave the system in this state for the next operation.

3.3 Verify IMU Orientation

The procedure to verify the correct orientation of the IMU is shown on Figure 3 and instructions for this test follow.

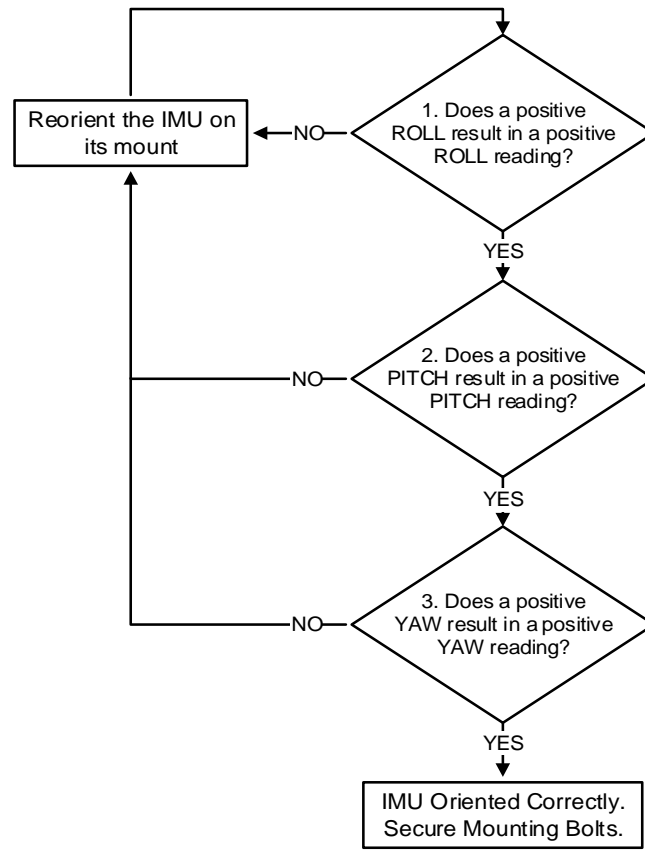


Figure 3. Procedure for Verifying IMU Orientation

1. Facing the direction of travel, rotate the IMU around the along-track axis to produce a positive ROLL as shown in Figure 4. Verify that the data acquisition system records a positive ROLL, Figure 5. If it does not, reorient the IMU on its mount and test again.

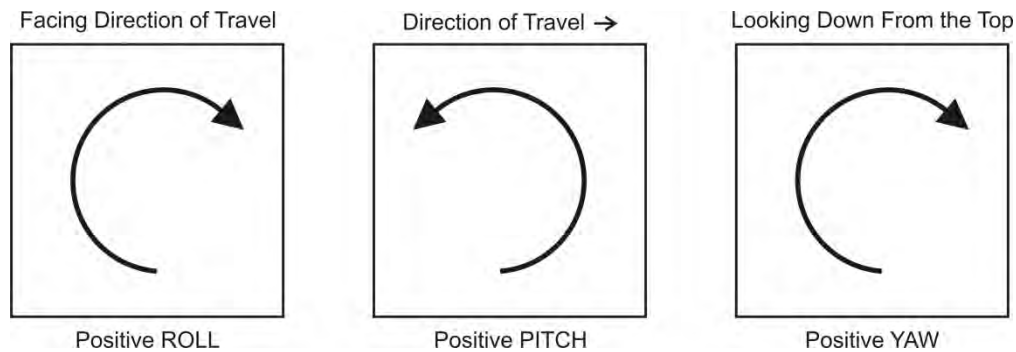


Figure 4. Positive ROLL, PITCH, and YAW Rotations of the IMU



Figure 5. Electronics Box Screen Showing Orientation Inputs

2. Standing on the side of the sensor with the direction of travel to your right, rotate the IMU around the cross-track axis to produce a positive PITCH as shown in Figure 4. Verify that the data acquisition system records a positive PITCH. If it does not, reorient the IMU on its mount and return to step 1.
3. Looking down on the sensor from above, rotate the IMU around the vertical axis to produce a positive YAW as shown in Figure 4. Verify that the data acquisition system records a positive YAW. If it does not, reorient the IMU on its mount and return to step 1.

3.4 Photograph the Sensor

Using a cell phone or other camera, photograph the installed sensor. Verify that the photograph(s) shows the locations and orientations of the GPS and IMU sensors.

3.5 Set up the Data Acquisition Parameters

In preparation for the sensor function test, use the [Setup] tab in TEMDataLogger or TEMTablet to set the correct data acquisition parameters for the dynamic survey. The easiest way to accomplish this is to use [Standard Dynamic] or [Standard Cued] button, Figure 6. The standard parameters are listed in Table 1.

Table 1. Standard Data Acquisition Parameters

Parameter	Cued Survey	Dynamic Survey
Acq Mode	Decimated	Decimated
Gate Width	5%	20%
Stacks	18	1
Repeats	9	3
Stack Period	0.9	0.033

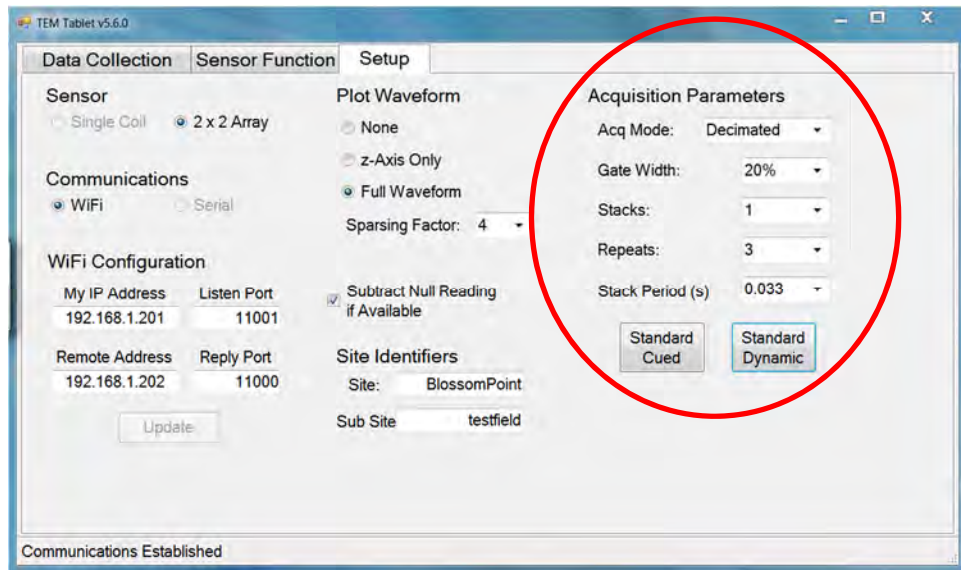


Figure 6. Standard Acquisition Parameters for Dynamic Surveys

3.6 Perform a Sensor Function Test

If there is a reference response for the combination of hardware and data acquisition parameters you are using, the [Sensor Function] tab will be available on the data acquisition computer. Access that tab to perform a sensor function test.

1. Position the sensor in a spot known to be clear of buried metal. Collect a background measurement from [Sensor Function] tab of the data acquisition software.
2. Without moving the sensor, mount the ISO80 test item in the hole on the top of the sensor housing (Figure 7, right panel)

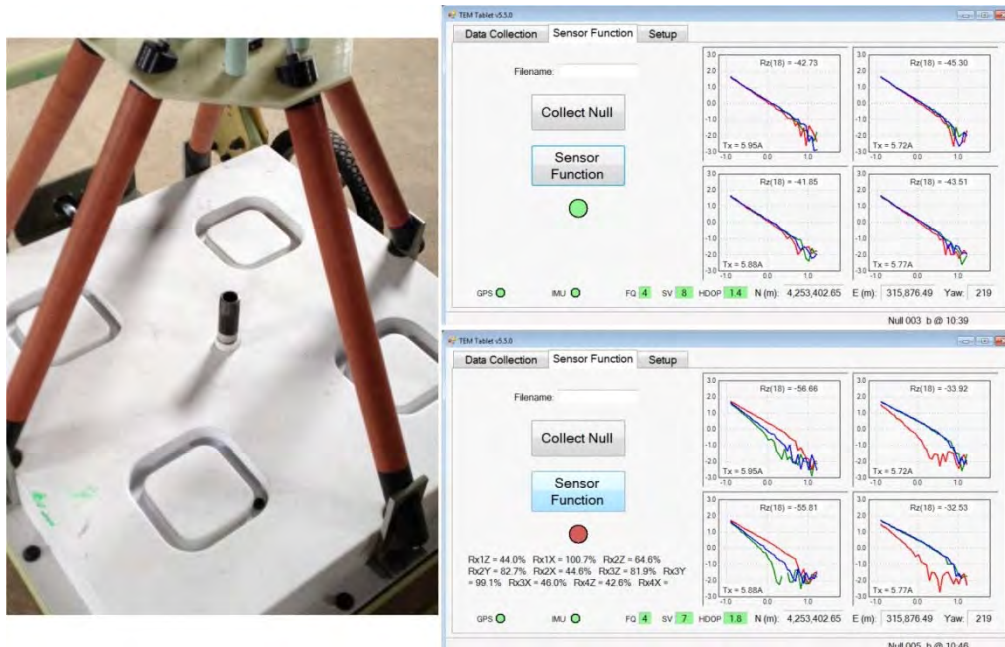


Figure 7. Test item Positioned for a Sensor Function Test (left panel) and Examples of the Test Results (right panels)

3. Collect sensor function data. If the results agree with the reference values, a green LED is displayed. If they do not agree, a red LED is displayed and a summary of the incorrect results is displayed.
4. Transfer the background and sensor function data files to the QC Geophysicist for archiving.

4 Data Management

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 Input Data Required

Input data consists of the assembly and operation instructions for the TEMTADS 2x2 contained in the unpacking instructions and user guide available from NRL.

4.2 Output Data

The sensor function test described in Section 3.6 will be saved in the project database. Also, the QC checklist in Attachment 1 of this SOP will be completed, signed, and filed with the assembly photograph(s) as proof of correct assembly.

5 Quality Control

As this definable feature of work is accomplished only during the preparatory phase, only preparatory QC checks will be performed on this activity. QC consists of performing the inspections on the Preparatory Phase Quality Control Checklist that is included as Attachment 1 to this SOP. This checklist will be completed by the Field or Project Geophysicist and will be reviewed by the QC Geophysicist who will document the implementation of this SOP.

5.1 Measurement Quality Objectives (MQOs)

The MQO (QAPP Worksheet #22) for this SOP is verification that the assembly instructions have been followed. The TEMTADS 2x2 will not be tested on the IVS (SOP MR-AC-02-01) until this has been documented as described below.

5.2 Reporting

Achievement of the Sensor Assembly MQO will be documented by the Field or Project Geophysicist by completion of the Preparatory QC Checklist in Attachment 1 to this SOP and will be verified by the QC Geophysicist.

The delivered data package for the assembled and tested TEMTADS will be included in a section of the IVS Letter Report titled “TEMTADS Assembly and Operation Verification” and will include:

- A brief description of the assembly and test process along with the photograph(s) required by Section 3.4 of this SOP
- The completed Preparatory QC Checklist signed by the Project or Field Geophysicists and checked by the QC Geophysicist verifying the assembly and orientation tests described above
- The sensor Function Test results

Attachment 1**SOP 1 Preparatory TEMTADS Assembly QC Checklist**

This checklist is to be completed by the Project or Field Geophysicist and checked by the QC Geophysicist during assembly and initial testing of the TEMTADS.

QC Step	QC Process and Guidance Reference	Yes/No	If no, provide comment below	Initial of Field or Project Geophysicist
1. Assembly	Is the TEMTADS assembled in accordance with the published instructions and in the sequence specified in Section 3.1?			
2. Testing: IMU orientation verification	Has the procedure and tests for verification of the IMU orientation been completed (Section 3.3)?			
3. Photograph the installation	Was a photograph showing the placement and orientation of the GPS and IMU taken?			
4. TEMTADS sensor function test	Was the TEMTADS sensor function test performed in accordance with Section 3.6 and were the results saved in the project database?			

Project or Field Geophysicist: _____ Date: _____

QC Geophysicist: _____ Date: _____

Perform Initial Dynamic Instrument Verification Strip (IVS) Survey – TEMTADS 2X2

1 Purpose

The purpose of this standard operating procedure (SOP) is to identify the means and methods to be employed when verifying the operation of an advanced digital geophysical mapping system prior to and during site surveys. The Instrument Verification Strip (IVS) is constructed of a series of buried inert munitions and/or industry standard objects (ISO). During the IVS process the advanced electromagnetic induction sensor system measures the amplitude response of each item in the IVS in dynamic mode and collects background noise data for leveling magnitude responses.

2 Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP. The following is a list of required equipment and materials:

- Naval Research Laboratory (NRL) TEMTADS 2x2 (TEMTADS) sensor coupled with a real-time kinematic Global Positioning System (RTK GPS) and Inertial Measurement Unit (IMU) for orientation measurements.
- Tablet PC
- Seed objects to place in the IVS
- Hand tools including shovels, pick axes, breaker bars, etc. to construct the IVS
- Tape measure (with centimeter scale)
- Digital camera
- White board with markers and eraser
- Wooden stakes and/or vinyl-stem pin flags (no red or white colors)*
- RTK GPS staff and data collector for recording positions of buried items

*These colors have specific designations when working on munitions response sites and should not be used for geophysical surveying

Information in this SOP assumes that an RTK GPS and IMU will be used with the system during data collection. If the TEMTADS is used for data collection in an area not suitable for use with GPS (e.g. under tree canopy), sections of this SOP pertaining to the RTK GPS will not apply. Similarly, if an IMU is not available for use with the system, sections of this SOP pertaining to the IMU will not apply.

2.1 Personnel and Qualification

The following individuals will be involved in the assembly verification of the TEMTADS:

- Project Geophysicist
- QC Geophysicist
- Field Geophysicist(s)
- Data Processor

- UXO Personnel will be responsible for overall daily site access and safety aspects of the project, compiling subcontractor health and safety documents, conducting daily safety briefings and performing MEC avoidance, as needed, in the field. Information on the specific qualifications for various UXO personnel support roles can be found in the project Health and Safety Plan.

The qualifications of the personnel implementing this SOP are documented in the Uniform Federal Policy (UFP) Quality Assurance Project Plan, Geophysical Classification for Munitions Response (GCMR QAPP), Worksheet #7.

3 Procedures and Guidelines

3.1 Advanced Digital Geophysical Mapping System

The advanced digital geophysical mapping (DGM) will be conducted using the TEM TADS sensor developed by NRL. This sensor has been extensively validated in a series of demonstrations conducted by the Department of Defense's Environmental Security Technology Certification Program (ESTCP). The TEM TADS is an advanced electromagnetic induction sensor designed for the detection and classification of buried metal objects. The sensor consists of four sensor elements arranged on 40-cm centers in a 2x2 array. Each sensor element consists of a 35-cm square transmit coil for target illumination with an 8-cm three-axis receive cube centered in the transmit coil. The transmitters are energized in sequence and the decay curve is recoded up to 25 ms after the transmitters are turned off for each of the 12 (4 cubes with 3 axes each) receive channels.

Positioning of the TEM TADS will be accomplished using RTK GPS. With adequate satellite visibility, RTK GPS can provide antenna locations with accuracies on the order of 5 cm. The TEM TADS orientation is measured using a six-degree-of-freedom IMU. Combining the sensor orientation and location measurements in this manner typically results in derived target locations within 15 cm of the ground truth.

3.2 Instrument Verification Strip Construction

Validation of the DGM system is accomplished using an IVS. Multiple IVS locations may be constructed during the project for convenience (for example, to avoid long travel times to reach the IVS on large sites). The construction details and verification procedures described in this document apply to each IVS location.

Location and Length of the IVS

IVS locations will be determined during initial site reconnaissance by the DGM field team. The IVS should be established in an area that is easily accessible, not prone to flooding and other weather-related phenomena, and is determined to be relatively free of subsurface metal objects. The IVS is constructed along a single transect approximately 30 m long. The IVS items, types and quantity to be determined and documented in the QAPP, including a blank, will be buried/established at approximate 5m intervals along this transect. The IVS site should be wide enough to accommodate transects on either side of the established IVS line at the project line spacing as well as an additional transect established 5m to the side to serve as a representative noise assessment line.

Seed Objects

Seed objects for the IVS can be either actual inert munitions or ISOs. Using inert munitions that match those expected to be found on the site is often preferable as this demonstrates to stakeholders that the system is able to accurately classify the exact munitions type(s) of concern. However, using an ISO is the technical equivalent and extraordinary measures to obtain inert munitions are not warranted.

An ISO, if used, should approximate the size of the munitions type(s) expected to be found on the site (if possible) and more than one type of ISO may be used if MEC of various sizes are expected. Either small, medium or large ISO, singly or in combination, can be selected. Table 1 shows the specifications for the three possible ISO and Figure 1 is a photograph of the three ISO.

Table 1. Industry Standard Objects Characterized for Use as Munitions Surrogates

Item	Nominal Pipe Size	Outside Diameter	Length	Part Number ¹	ASTM Specification
Small ISO	1"	1.315" (33 mm)	4" (102 mm)	4550K226	A53/A773
Medium ISO	2"	2.375" (60 mm)	8" (204 mm)	44615K529	A53/A773
Large ISO	4"	4.500" (115 mm)	12" (306 mm)	44615K137	A53/A773

¹ Part number from the McMaster-Carr catalog (<http://www.mcmaster.com/>).



Figure 1. Small, Medium, and Large Industry Standard Objects (ISOs)

IVS Procedures

Figure 2 illustrates the overall IVS process and the procedures to be followed during the site selection, emplacement, and use of the IVS.

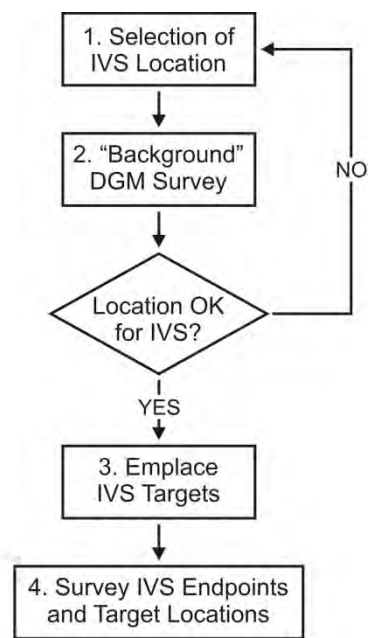


Figure 2. IVS Site Selection, Emplacement, and Documentation

1. An IVS location will be selected with preference for the following (although none of the conditions are vital for IVS success):
 - Terrain, geology, and vegetation similar to that of a majority of the DGM survey area.
 - Geophysical noise conditions similar to those expected across the survey area.
 - Large enough site to accommodate all necessary IVS tests and equipment and for adequate spacing (at least 3-m separation and preferably greater) of the ISO items to avoid ambiguities in data evaluation.
 - Readily accessible to project personnel.
 - Close proximity to the actual survey site (if not within the site).
2. A background DGM survey will be performed with the TEMTADS or other DGM instrument using RTK GPS. The purpose of this step is to document the appropriateness of the location (e.g. few existing anomalies), and will verify that IVS targets are not seeded near existing anomalies. The data from this IVS pre-survey will be processed and provided to the Project, Field and QC Geophysicists for evaluation.
3. Once the IVS area is deemed suitable for use, (i.e. free of significant subsurface anomalies or containing anomalies that are clearly identified so that they can be avoided during seeding), the targets shall be buried at depths below ground surface of approximately 3 and 7 times their diameter, unless otherwise specified in the QAPP. (These depths are intended to provide adequate signal to noise ratio for detecting the targets.) Some of the items should be placed horizontally (most difficult to detect) and some vertically (easiest to detect). The generalized diagram of the seeded IVS transect is presented as Figure 3, using an example of 4 targets and a blank space.

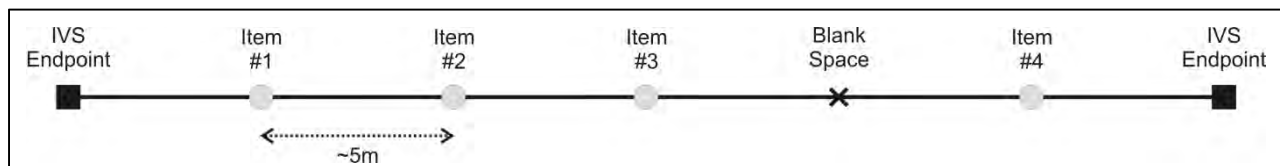


Figure 3. Example Layout of the IVS

Measurements of the item depths will be to the center of mass of each item. On-site personnel will bury the IVS targets using shovels to dig the holes to the appropriate depths for burial of the seed items in coordination with the QC Geophysicist. UXO personnel will implement MEC avoidance procedures using analog instruments during installation. The background survey data and anomaly avoidance techniques will be reviewed so that transect start and end stakes and the seed items are not placed on top of or near existing anomalies. IVS construction personnel will bury the ISOs and record the following information:

- Transect endpoints
- Target type(s)
- Target emplacement locations
- Target emplacement depths
- Target emplacement orientations

- The holes will then be filled with soil and a wooden survey stake or other suitable non-metallic marker will be placed at each buried item location as well as the start and end location of the IVS. Wooden stakes will not extend more than 3 inches above the ground surface to prevent interference with the TEM TADS when passing over them.

3.3 Initial IVS Survey

The initial IVS survey will be completed prior to collecting production data. The TEM TADS assembly and function tests presented in SOP MR-AC-01-01 will be completed.

During the initial IVS survey, a total of 4 dynamic data transects will be collected with the TEM TADS over the IVS and one dynamic data transect performed over the background area (which should be between 3-5 meters offset from the IVS) as depicted on **Figure 4**. Three of the IVS transects will be performed at the intended survey line spacing, with the center of these three directly over the IVS targets (transects A, B, and D on **Figure 4**). The fourth transect will be performed offset from the IVS by $\frac{1}{2}$ the intended line spacing to assess detection capability of targets situated between lines.

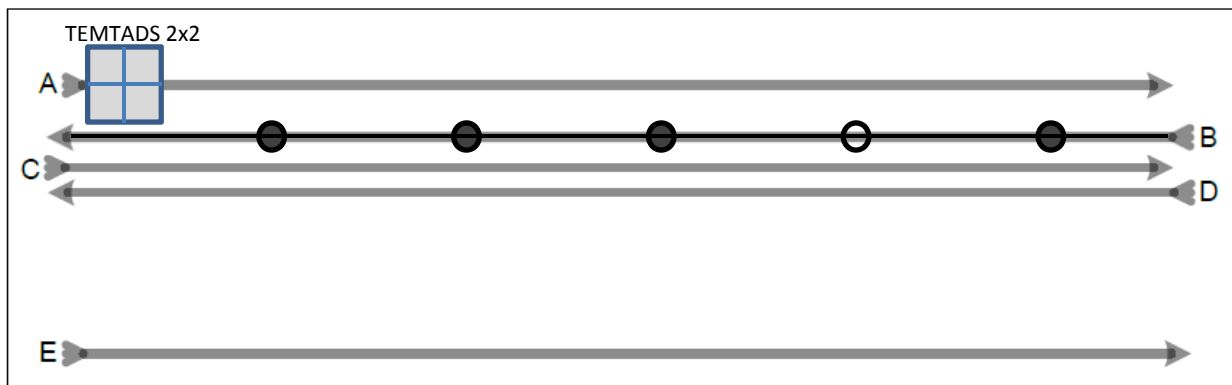


Figure 4. Dynamic Transect Locations for the Initial IVS Survey

The data from these transects will be processed in the same manner as the detection survey data and will be used to verify that the MQOs presented in QAPP Worksheet #22 for the initial IVS survey are met. Once the initial IVS survey MQOs have been met, the IVS survey will be complete and the system and operators verified for field data collection.

4 Data Management

The IVS construction details (IVS item description, location, depth and orientation) will be archived in digital form. The raw and processed IVS background data well as the raw and processed initial IVS survey data will be archived in a suitable format and summarized in the IVS Technical Memorandum.

5 Quality Control

Quality control (QC) for this activity will be achieved through completion of the checklist presented as Attachment 1. This checklist will be filled out and signed by the Field Geophysicist(s), Project Geophysicist, and Data Processor.

The activities described in this SOP are being performed in support of QC for an advanced sensor detection survey. The MQOs for the initial IVS survey are presented are presented in Worksheet #22 of the QAPP. The TEM TADS will not be used for field data collection until it is able to meet these MQOs or

until an appropriate corrective action (CA) is determined, the project team agrees to the CA, and it is successfully implemented.

6 Reporting

The IVS construction and initial survey results will be documented in an IVS Technical Memorandum. This report will include information on the following:

- IVS location and setup
- IVS item descriptions including types, locations, depths and orientation
- Sensor(s) system performance against the MQOs established for the initial IVS survey including response amplitude, item position, and system noise levels
- Completed checklists from SOPs MR-AC-01-01 and MR-AC-02-01

Attachment 1

SOP MR-AC-02-01 Dynamic Instrument Verification Strip (IVS) Survey QC Checklist

This checklist is to be completed by the Field Geophysicist(s) or Project Geophysicist during construction and initial survey of the IVS.

QC Step	QC Process	Yes/No	Initial of Field or Project Geophysicist
1. IVS Construction	Has an appropriate location for the IVS been selected and verified as suitable using a background geophysical survey?		
2. IVS Construction	Have appropriate IVS seed targets been selected and procured?		
3. IVS Construction	Were the target seeds buried appropriately, backfilled and marked?		
4. IVS Construction	Is the required data on the IVS construction from Section 3.2 recorded for inclusion in the IVS Technical Memorandum?		
5. Initial IVS Survey	Is the IVS data collected in accordance with Section 3.3?		
6. Initial IVS Survey	Have the MQOs for the initial IVS survey on Worksheet #22 been achieved?		

Field Geophysicist: _____ Date: _____

Project Geophysicist: _____ Date: _____

Data Processor: _____ Date: _____

Perform Dynamic Surveys with TEMTADS 2x2

1 Purpose

The purpose of this Standard Operating procedure (SOP) is to identify the means and methods to be employed when performing dynamic surveys using a TEMTADS 2x2 (TEMTADS) advanced electromagnetic induction (EMI) sensor for target detection.

Dynamic TEMTADS data collection involves navigating the sensor along transects at a transect spacing designed to meet the project objectives with respect to detection performance of suspected targets of interest (TOI) in the subsurface. The detection objectives and resultant transect spacing are identified in the QAPP.

The observed signal measured by the TEMTADS is composed of 1) the EMI response of potential buried targets, 2) the self-signature of the sensor system, and 3) any response from the ambient environment in which the target is buried. To isolate responses associated with buried discrete metal objects, a background model comprised of the latter two contributing signals must be derived and removed from the raw data. The resulting 'leveled' signal data, (raw data – background model) are used as inputs into a detection algorithm where anomalous responses due to potential targets of interest are mapped and selected for further investigation. Details of the data processing and analysis of dynamic data are covered in MR-AC-04-01.

2 Personnel, Equipment and Materials

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 Personnel and Qualifications

The following individuals will be involved in the collection of dynamic survey data:

- Project Geophysicist
- QC Geophysicist
- Field Geophysicist(s)
- Data Processor

The qualifications of the personnel implementing this SOP are documented in the Uniform Federal Policy (UFP) Quality Assurance Project Plan, Geophysical Classification for Munitions Response (GCMR QAPP), Worksheet #7.

2.2 Equipment

The following is a list of required equipment and materials:

- TEMTADS sensor coupled with a real-time kinematic Global Positioning System (RTK GPS) and orientation sensor
- Tablet PC
- Field survey grade tape measure

2.3 Materials

Non-metallic materials to use for maintaining line spacing (e.g. traffic cones, marking paint, bean bags, etc.)

3 Procedures and Guidelines

3.1 Survey Grid Preparation

Grid preparation involves demarking the site boundaries and survey transects required to achieve the coverage specified in the QAPP. The site will be subdivided into grids with sizes depending upon the site conditions such that the sensor can be precisely navigated along the desired transect.

3.2 Function Test Measurements

Function test measurements (described in SOP MR-AC-01-01) will be performed prior to each sortie to confirm that all transmit and receive components of the TEMTADS sensor are operational.

3.3 Daily IVS Survey

Prior to the start and at the end of each day of data collection, measurements of the set of IVS targets will be performed (described in SOP MR-AC-03-01).

3.4 Dynamic Data Collection

Dynamic survey for DGM involves collecting data along transects across the survey area. In combination with SOPs for sensor assembly (SPO MR-AC-01-01) and testing at the IVS (SOP MR-AC-02-01), in-motion data is collected along each transect at a spacing appropriate to the site and project needs, as defined in the UFP QAPP. Data collection is controlled by the user with the EM-3D software, which allows the user to assign a numerical ID to each transect line and start/stop data collection at the beginning/end of each transect. When an obstacle is encountered along a transect, the obstacle can be avoided by either altering the path of the transect or stopping data collection when the obstacle is encountered and resuming a new ID transect on the other side of the obstacle. Data gaps that are the result of obstacles should be recorded by the field geophysicist and submitted to the data processor. Data gaps that are the result of line spacing over the defined acceptable spacing will be determined by the data processor and provided to the field geophysicist for recollection. Data acquisition will be performed using the following steps:

1. **Start-up and test the TEMTADS.** The geophysical and navigation systems are started and a function test is performed prior to every data collection sortie. In addition the data acquisition software is monitored to ensure that all data streams (EMI, global positioning system, [GPS], and inertial measurement unit [IMU]) are valid and being recorded.
2. **Navigate and collect data along transects.** Navigation along transects is performed visually with the assistance of markers, which are determined at the discretion of the field geophysicist (see Section 2.3). This can be accomplished by marking the track of the inside wheels as the sensor moves along a transect. Positioning in the data is captured through the use of the RTK GPS system and the IMU. Data collection along each transect will start and end at least one full TEMTADS 2x2 sensor length beyond the edge of the grid. This process facilitates full coverage of the survey grids and minimizes the occurrence of data gaps at grid edges. In addition, at the start of each new grid, data collection

will begin with the last transect fully contained within the adjacent grid. This overlap data is used primarily to support advanced geophysical analysis of the dynamic survey data. For survey grids along the survey area boundary, dynamic data collection will include at least one transect collected fully beyond the outer edge of the subject grid.

3. **Verify the integrity and quality of the collected data.** During data acquisition, the integrity and quality of the data will be verified by the operator by inspection of the TEMTADS data collection screen to ensure that:
 - The data collection start and stops in coordination with the beginning and end of each transect
 - Each transect is assigned a unique numerical identifier (ID) or file name in EM3D Acquire, in sequential order
 - The amplitude responses measured by each receiver coil appear reasonable (i.e., not 'flat-lined')
4. **Verify complete coverage of survey area.** 100% coverage surveys will require appropriate line spacing (presented in QAPP Worksheet #12). Data gaps resulting from obstacles or inaccessible terrain will be marked and verified by the field geophysicist. Data gaps exceeding the MQOs identified in QAPP Worksheet #22 will be reacquired using RTK GPS and recollected.

4 Data Management

4.1 Data inputs

The data inputs required for performing a cued advanced analysis data acquisition are:

- A list of coordinates identifying the site boundaries
- A list of instrument verification strip (IVS) transect start and end points

4.2 Data Outputs

The data outputs of the cued advanced analysis data acquisition are:

- Dynamic TEMTADS transect data over the IVS line and survey area
- Function test measurement data
- Raw field notes (pdf images of hand written notes)
- Digital field notes (an excel or other digitally recorded table presenting data filenames as delivered and rectified field notes [i.e. differences between delivered digital filenames and field notes are resolved])

5 Quality Control

Practical considerations limit the real-time quality control (QC) of the dynamic data acquisition activities to qualitative assessments. Quantitative QC and assessment of the collected data will be performed as part of SOP MR-AC-4-01 dealing with the processing of dynamic TEMTADS detection data. Results documenting QC checks performed on the dynamic data are provided as part of the delivered data package for each sortie. This documentation includes the results of the QC tests, name, and date of the review performed by the QC Geophysicist.

5.1 Measurement Quality Objectives (MQOs)

The MQOs for dynamic data acquisition are presented in Worksheet #22 of the QAPP. Performance relative to the MQOs will be assessed during the processing of the collected data (SOP MR-AC-04-01). If it is determined during data processing that an MQO has not been met for the dynamic survey, a root cause analysis (RCA) will be performed and a corrective action (CA) determined. Dynamic TEMTADS data will not be used to select targets until the project team agrees on the CA and it is successfully implemented.

6 Reporting

Reporting of the activities associated with this SOP will consist of the digital copies of the field notes and data files submitted to the Data Processor.

Process Dynamic Survey Data - TEMTADS 2x2

1 Purpose

The purpose of this Standard Operating procedure (SOP) is to identify the means and methods to be employed when processing dynamic survey data collected using a TEMTADS 2x2 (TEMTADS) advanced electromagnetic induction (EMI) sensor for target detection.

Dynamic TEMTADS data collection involves navigating the sensor along transects at a transect spacing designed to meet the project objectives with respect to detection performance of suspected targets of interest (TOI) in the subsurface. The detection objectives and resultant transect spacing are identified in the Uniform Federal Policy (UFP) Geophysical Classification for Munitions Response Quality Assurance Project Plan (GCMR-QAPP), hereafter referred to as the QAPP. Processing the dynamic data involves processing and assessing all QC tests (including daily function tests and IVS surveys), leveling the raw data to remove EMI signal due to the self signature of the sensor systems and the ambient EMI soil response, and target selection.

A set of QC measurements are conducted upon initial commissioning of the system and on a daily basis to validate the operation of the various components of the TEMTADS dynamic survey system.

In the dynamic survey data, the observed signal measured by the TEMTADS is composed of 1) the EMI response of potential buried metallic objects, 2) the self-signature of the sensor system, and 3) any response from the ambient environment in which the target is buried. To isolate responses associated with buried discrete metal objects, a background model comprised of the latter two contributing signals must be derived and removed from the raw data. The resulting 'leveled' signal data, (raw data – background model) are used as inputs into a detection algorithm where anomalous responses due to potential TOI are mapped and selected for further investigation.

2 Personnel and Equipment

This section describes the personnel and equipment required to implement this SOP.

2.1 Personnel and Qualifications

The following individuals will be involved in the collection of dynamic data:

- Project Geophysicist
- QC Geophysicist
- Data Processor

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #7.

2.2 Equipment

The only required equipment is a data processing computer suitable for and equipped to run the processes provided in the UX-Advanced module of Geosoft's Oasis Montaj geophysical processing environment.

3 Procedures and Guidelines

This section describes the procedures used to process the dynamic production data including positioning and leveling of the data, process/assess the QC activities related to dynamic data collection, and select target anomalies from the final processed data.

3.1 Processing of Dynamic TEMTADS data

The processing of dynamic TEMTADS data is achieved in the following steps:

1. Data conversion and import
2. QC data processing
3. Production TEMTADS data processing
4. Target selection

3.1.1 Data Conversion and Import

The raw instrument data files (*.TEM) are converted to ASCII *.CSV file for QC and production data processing. Once imported the data are inspected and assessed against the measurement quality objectives (MQOs) provided in Worksheet #22 depending on data type (QC or production DGM).

3.1.2 QC Data Processing

During the course of a dynamic survey, QC measurements are performed on a daily basis to verify the operation of the sensor and associated components. These tests are comprised of function tests (described in SOP MR-AC-01-01) and transects along the instrument verification strip (IVS). The successful completion of these tests on a daily basis is required to validate the survey data collected on that day. The processing of QC data involves analysis of the sensor function test and IVS data to ensure that MQOs are being achieved for each sensor being used for data collection.

Processed sensor function test data shall include the following outputs:

- Background corrected sensor response values
- Sensor function test tracking sheet (*.xlsm format)
- Raw instrument files

Processed IVS data shall include the following outputs:

- Calculated latency/lag correction
- Seed item offsets
- Seed item response amplitudes
- Geosoft IVS Map Plots (*.MAP (Packed) and *.PDF format)
- IVS target list in Geosoft Database (*.GDB) format
- Processed IVS data in Geosoft Database (*.GDB) and ASCII (*.XYZ) formats
- Raw instrument files

QC tracking sheets will be used to monitor the ongoing sensor function and IVS results for each TEMTADS system. A QC report will be included with each QC data delivery. Measured IVS seed item responses will be tabulated and compared against predicted seed item responses.

QC data will be delivered by date in a QC directory on the FTP site. The raw data directory shall contain either the original raw instrument files as downloaded from the instrument. The merged data directory shall contain the positioned data files (if created) and raw .xyz files. The processed data directory shall contain the final Geosoft data files. Finally, the Images directory shall contain the PDF format files associated with the various QC tests.

3.1.3 Production DGM Data Processing

The processing of the production DGM data requires analysis of the data to ensure that project-specific MQOs are being achieved in each dataset acquired. Data measurements that do not pass the MQOs are automatically identified by a series of automated processing routines that are used to flag data where the MQOs are not met. This maintains the chronologic integrity of the EMI data and prevents the out-of-specification data from being used for detection.

Once imported the data are inspected and assessed against the measurement quality objectives (MQOs) provided in Worksheet #22 for:

- Along-line measurement spacing (sample-separation)
- Velocity
- Cross-line spacing (survey coverage)
- Transmit (Tx) current within limits
- Global positioning system (GPS) fix quality
- Valid inertial measurement unit (IMU) data
- EMI response signal not saturated

Project-specific metrics will be calculated and documented in MRSIMS on a per-dataset or per-survey unit (grid, grid block, etc...) basis. If data fails any of the project specified metrics, the QC geophysicist and field team will be notified, and the data will be issued for recollection. After the raw data MQOs have been verified, further processing of the DGM data will be performed.

3.1.4 Data Positioning and Leveling

A second purpose-built software routine automatically assigns the monostatic, Z-component EMI measurements positions based upon the GPS antenna location, platform geometry and platform attitude (IMU) data. A site-specific de-median filter is applied to the raw monostatic, Z-component data to derive an estimate of the background model. This model is subtracted from the raw data to provide a background removed or 'leveled' data set.

The leveled monostatic data are gridded gridded using a Geosoft gridding algorithm (e.g. Minimum Curvature). The gridded monostatic Z-component data are then used for amplitude response based target selection whereby the position of peak responses in the data that exceed the project threshold are selected and identified as target anomalies for further analysis.

The gridded and mapped monostatic Z-component data are also suitable for use to select background locations, which in turn can be used to level all of the 48 Tx/Receive (Rx) coil combination data in a manner similar to that used for background removal of cued target measurements.

3.1.5 Target Selection

Target selection using the TEMTADS dynamic data is performed using the traditional amplitude response metric using the mapped Z-component data described above. Alternately a dipole response filter approach can be used.

Response Amplitude Detection:

Response amplitude anomaly selection is performed using an automatic grid peak detection algorithm in Geosoft (e.g. Blakely Test) using the project specific target selection threshold on the designated sensor, or sensor channel(s). After the data have been gridded, the Geosoft automatic grid peak detection algorithm is used to extract locations of all grid peaks that are above the project detection threshold.

Anomalies will be assigned a unique target ID which incorporates a grid or survey area identifier. To maintain the integrity and continuity of the initial picked target list, target IDs will incorporate the original Geosoft target ID as assigned by the grid peak detection algorithm.

Manual review of all anomalies will be performed by the processing geophysicist, and any anomalies found to be invalid or incorrectly located will be adjusted or removed. Depending on project needs, anomalies may be categorized based on calculated characteristics (e.g. response, size, signal-to-noise ratio, source, etc.) however, this is not a requirement. The final list will be reviewed by the quality control (QC) geophysicist prior to finalization of the target list.

Dipole Response Filter Detection:

The 'dipole response filter' approach to anomaly detection makes use of the rich data set output of the advanced sensors. This target selection routine takes advantage of all the measured data – not just the monostatic Z component – by employing an automated dipole inversion routine to estimate the source locations. The process involves:

1. Assuming a target's location (at every 10 centimeter [cm] spaced grid node across the site)
2. Extracting data within a specified sensor footprint
3. Inverting for dipole polarizations
4. Extracting the 'goodness-of-fit parameter' as the detection metric

The 'goodness-of-fit' filter output is the squared correlation between the full multi-axis, multi-static TEMTADS data set and a dipole model fit to those data. This filter output is mapped in the same manner as the amplitude response and peaks in the detection metric indicate target locations as illustrated by Figure 1.

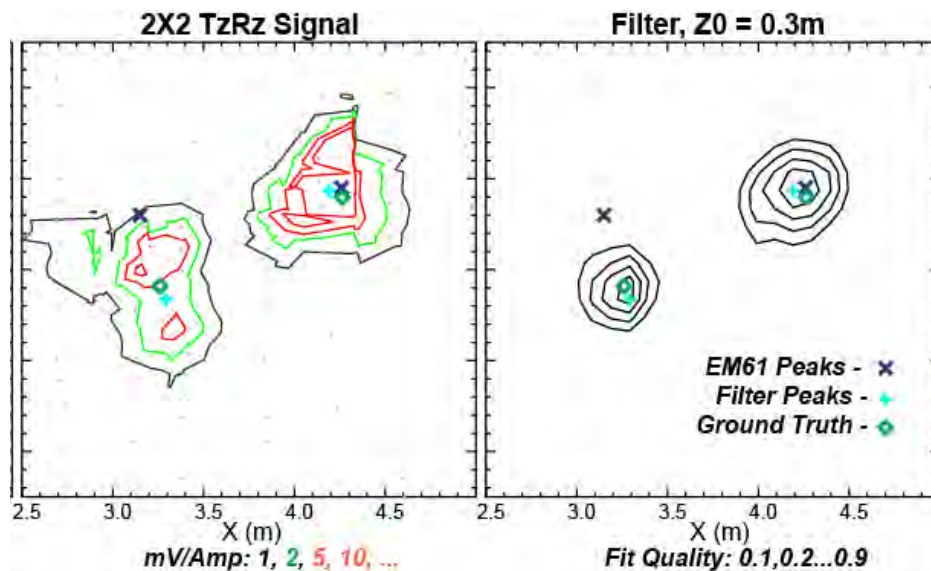


Figure 1. Data subset showing mapped response amplitude (left) and mapped filter response output (right) with ground truth information superimposed. Contour line values are provided in the legend.

Accordingly, target selection using the dipole filter fit coherence metric is accomplished in the same manner as for the amplitude response approach. After running the automatic peak detection routine, the target list will be reviewed and manual additions/deletions will be made.

3.1.6 Processed DGM Data outputs

Processed DGM data shall include the following outputs:

- Processed DGM data in Geosoft Database (*.GDB) and ASCII (*.XYZ) formats
- Final target list per grid in Geosoft Database (*.GDB) format and ASCII (*.XYZ) formats
- Geosoft Map Plot (Packed) per grid or survey area (*.MAP and *.PDF format)

Processed DGM data will be delivered by grid in the processed data directory on the FTP site. The raw data directory shall contain the original raw instrument files as downloaded from the instrument. The merged data directory shall contain the positioned data files (if created) and raw .xyz files. The processed data directory shall contain the final Geosoft data files. Finally, the Images directory shall contain the PDF format files associated with the various QC tests.

4 Data Management

4.1 Data inputs

The data inputs required for processing dynamic TEMTADS data are:

1. A list of coordinates identifying the site boundaries
2. Raw Dynamic TEMTADS data files
3. Amplitude response minimum detection threshold (derived from the QAPP)

4.2 Data Outputs

The data outputs of the processing of dynamic TEMTADS data are:

1. QC reports summarizing daily QC measurement results
2. Mapped detection metric data (Z-component amplitude and dipole response coherence) in ASCII (x,y,z) format
3. Target anomaly list (identifier [ID], X, Y)
4. Letter report detailing processing approach including leveling and target selection procedures

5 Quality Control

Results documenting QC checks performed on the dynamic data are provided as part of the delivered data package for each sortie. This documentation includes the results of the QC tests, name, and date of the review performed by the QC Geophysicist.

5.1 Measurement Quality Objectives (MQOs)

The MQOs for processing dynamic TEMTADS data are presented in Worksheet #22 of the QAPP. Performance relative to the MQOs will be assessed during the processing of the data. Dynamic

TEMTADS data will not be used to select targets until these MQOs are met or until the project team agrees on modifications to these MQOs.

6 Reporting

Upon completion of the data processing and entry of the DGM processing forms in MRSIMS, data are assembled into a final delivery package that includes the following:

- Raw instrument *.TEM files per grid or survey area
- Positioned pre-processed ASCII *.CSV files
- QC report summarizing daily QC results (Function tests and IVS tests)
- QC data by date as detailed in section **Error! Reference source not found.**
- Raw DGM data per grid or survey area in Geosoft Database (*.GDB) format
- Processed DGM data per grid or survey area in Geosoft Database (*.GDB) format
- Final target list per grid or survey area in Geosoft Database (*.GDB) format
- Geosoft Map Plot (Packed) per grid or survey area (*.MAP and *.PDF format)
- MRSIMS Final Data Delivery Report

Processed DGM data will be delivered by grid in the final data directory on the FTP site.

Perform Initial Cued Instrument Verification Strip (IVS) Survey – TEMTADS 2x2

1 Purpose

The purpose of this SOP is to identify the means and methods to be employed when verifying the operation of an advanced digital geophysical mapping system prior to and during site surveys. The Instrument Verification Strip (IVS) is constructed of a series of buried inert munitions and/or industry standard objects (ISO). During the IVS process the advanced electromagnetic induction sensor system measures the amplitude response of each item in the IVS in dynamic mode and collects background noise data for leveling magnitude responses.

2 Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP. The following is a list of required equipment and materials:

- Naval Research Laboratory (NRL) TEMTADS 2x2 (TEMTADS) sensor coupled with a real-time kinematic Global Positioning System (RTK GPS) and Inertial Measurement Unit (IMU) for orientation measurements.
- Tablet PC
- Inert munitions, ISOs, and surrogates to place in the IVS
- Hand tools including shovels, pick axes, breaker bars, etc. to construct the IVS
- Tape measure (with centimeter scale)
- Digital camera
- White board with markers and eraser
- Wooden stakes and/or vinyl-stem pin flags (no red or white colors)*
- RTK GPS staff and data collector for recording positions of buried items

*These colors have specific designations when working on munitions response sites and should not be used for geophysical surveying

Information in this SOP assumes that an RTK GPS and IMU will be used with the system during data collection. If the TEMTADS is used for data collection in an area not suitable for use with GPS (e.g. under tree canopy), sections of this SOP pertaining to the RTK GPS will not apply. Similarly, if an IMU is not available for use with the system, sections of this SOP pertaining to the IMU will not apply.

2.1 Personnel and Qualification

The following individuals will be involved in the assembly verification of the TEMTADS:

- Project Geophysicist
- QC Geophysicist
- Field Geophysicist(s)
- Data Processor

- UXO Personnel will be responsible for overall daily site access and safety aspects of the project, compiling subcontractor health and safety documents, conducting daily safety briefings and performing MEC avoidance, as needed, in the field. Information on the specific qualifications for various UXO personnel support roles can be found in the project Health and Safety Plan.

The qualifications of the personnel implementing this SOP are documented in the Uniform Federal Policy (UFP) Quality Assurance Project Plan, Geophysical Classification for Munitions Response (GCMR QAPP), Worksheet #7.

3 Procedures and Guidelines

3.1 Advanced Digital Geophysical Mapping System

The advanced digital geophysical mapping (DGM) will be conducted using the TEMTADS sensor developed by NRL. This sensor has been extensively validated in a series of demonstrations conducted by the Department of Defense's Environmental Security Technology Certification Program (ESTCP). The TEMTADS is an advanced electromagnetic induction sensor designed for the detection and classification of buried metal objects. The sensor consists of four sensor elements arranged on 40-cm centers in a 2x2 array. Each sensor element consists of a 35-cm square transmit coil for target illumination with an 8-cm three-axis receive cube centered in the transmit coil. The transmitters are energized in sequence and the decay curve is recoded up to 25 ms after the transmitters are turned off for each of the 12 (4 cubes with 3 axes each) receive channels.

Positioning of the TEMTADS will be accomplished using RTK GPS. With adequate satellite visibility, RTK GPS can provide antenna locations with accuracies on the order of 5 cm. The TEMTADS orientation is measured using a six-degree-of-freedom IMU. Combining the sensor orientation and location measurements in this manner typically results in derived target locations within 15 cm of the ground truth.

3.2 Instrument Verification Strip Construction

Validation of the DGM system is accomplished using an IVS. Multiple IVS locations may be constructed during the project for convenience (for example, to avoid long travel times to reach the IVS on large sites). The construction details and verification procedures described in this document apply to each IVS location.

Location and Length of the IVS

IVS locations will be determined during initial site reconnaissance by the DGM field team. The IVS should be established in an area that is easily accessible, not prone to flooding and other weather-related phenomena, and is determined to be relatively free of subsurface metal objects. The IVS is constructed along a single transect approximately 30 m long. The IVS items, types and quantity to be determined and documented in the QAPP, including a blank, will be buried/established at approximate 5m intervals along this transect. The IVS site should be wide enough to accommodate additional parallel transects on either side of the IVS seeded transect at spacings of 0.25 m and 0.5 m as well as an additional transect spaced approximately 5m from the seeded transect to serve as a representative noise assessment line.

Seed Objects

Seed objects for the IVS can be either actual inert munitions or ISOs. Using inert munitions that match those expected to be found on the site is often preferable as this demonstrates to stakeholders that the

system is able to accurately classify the exact munitions type(s) of concern. However, using an ISO is the technical equivalent and extraordinary measures to obtain inert munitions are not warranted.

An ISO, if used, should approximate the size of the munitions type(s) expected to be found on the site (if possible) and more than one type of ISO may be used if MEC of various sizes are expected. Either small, medium or large ISO, singly or in combination, can be selected. Table 1 shows the specifications for the three possible ISO and Figure 1 is a photograph of the three ISO.

Table 1. Industry Standard Objects Characterized for Use as Munitions Surrogates

Item	Nominal Pipe Size	Outside Diameter	Length	Part Number ¹	ASTM Specification
Small ISO	1"	1.315" (33 mm)	4" (102 mm)	4550K226	A53/A773
Medium ISO	2"	2.375" (60 mm)	8" (204 mm)	44615K529	A53/A773
Large ISO	4"	4.500" (115 mm)	12" (306 mm)	44615K137	A53/A773

¹ Part number from the McMaster-Carr catalog (<http://www.mcmaster.com/>).



Figure 1. Small, Medium, and Large Industry Standard Objects (ISOs)

IVS Procedures

Figure 2 illustrates the overall IVS process and the procedures to be followed during the site selection, emplacement, and use of the IVS.

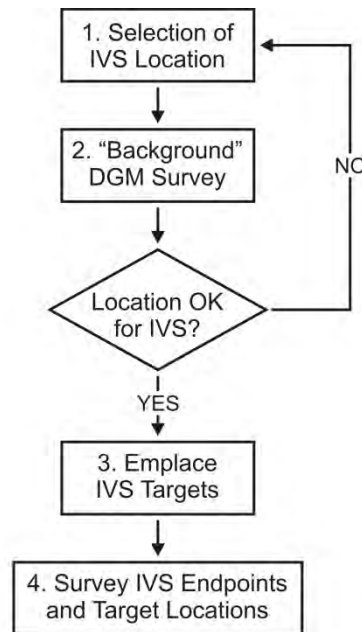


Figure 2. IVS Site Selection, Emplacement, and Documentation

1. An IVS location will be selected with preference for the following (although none of the conditions are vital for IVS success):
 - Terrain, geology, and vegetation similar to that of a majority of the DGM survey area
 - Geophysical noise conditions similar to those expected across the survey area
 - Large enough site to accommodate all necessary IVS tests and equipment and for adequate spacing (at least 3-m separation and preferably greater) of the ISO items to avoid ambiguities in data evaluation
 - Readily accessible to project personnel
 - Proximity to the actual survey site (if not within the site)
2. A background DGM survey will be performed with the TEMTADS or other DGM instrument using RTK GPS. The purpose of this step is to document the appropriateness of the location (e.g., few existing anomalies), and will verify that IVS targets are not seeded near existing anomalies. The data from this IVS pre-survey will be processed and provided to the Project, Field and QC Geophysicists for evaluation.

- Once the IVS area is deemed suitable for use, (i.e., free of significant subsurface anomalies or containing anomalies that are clearly identified so that they can be avoided during seeding), the targets shall be buried at depths below ground surface of approximately 3 and 7 times their diameter, unless otherwise specified in the QAPP. (These depths are intended to provide adequate signal to noise ratio for detecting the targets.) Some of the items should be placed horizontally (most difficult to detect) and some vertically (easiest to detect). The generalized diagram of the seeded IVS transect is presented as Figure 3, using an example of 4 targets and a blank space.

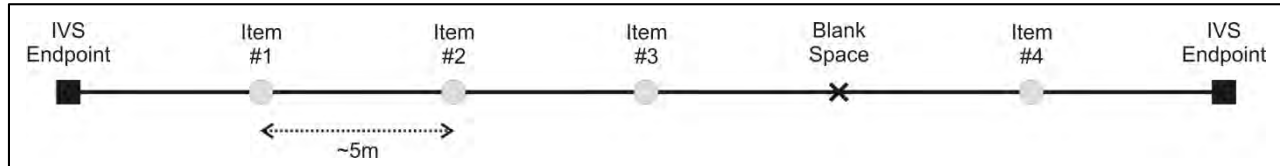


Figure 3. Example Layout of the IVS

Measurements of the item depths will be to the center of mass of each item. Onsite personnel will bury the IVS targets using shovels to dig the holes to the appropriate depths for burial of the seed items in coordination with the QC Geophysicist. UXO personnel will implement MEC avoidance procedures using analog instruments during installation. The background survey data and anomaly avoidance techniques will be reviewed so that transect start and end stakes and the seed items are not placed on top of or near existing anomalies. IVS construction personnel will bury the ISOs and record the following information:

- Transect endpoints
 - Target type(s)
 - Target emplacement locations
 - Target emplacement depths
 - Target emplacement orientations
- The holes will then be filled with soil and a wooden survey stake or other suitable non-metallic marker will be placed at each buried item location as well as the start and end location of the IVS. Wooden stakes will not extend more than 3 inches above the ground surface to prevent interference with the TEMTADS when passing over them.
 - Measurements need to be collected precisely over the seeded item, and the instrument needs to be positioned with the cart at the same heading, regardless of operator. If the IVS is on a slope, the wheels will be secured to prevent accidental movement of the cart during measurements. This can be accomplished by adding additional wooden stakes or non-metallic markers that would enable the TEMTADS 2x2 to be repeatedly positioned in as close to the same location each time the IVS seed items are measured.

3.3 Initial IVS Survey

The initial IVS survey will be completed prior to collecting production data. The TEMTADS assembly and function tests presented in SOP MR-AC-01-01 will be completed.

In addition to the original background survey, the background location will be verified as suitable by collection of a series of 5 measurements: the first centered at the location and the next four offset by ½ sensor spacing in each cardinal direction. Significant deviation in responses between these

measurements will indicate a localized source at this location, rendering it unsuitable as a background location. If this is the case an alternative location will be identified and confirmed using the same procedure.

After confirming the suitability of the background location, a set of static cued measurements will be collected over each of the IVS items. The data from these measurements will be processed in the same manner as planned for the cued production survey data and will be used to verify that the MQOs presented in Worksheet #22 for the initial cued IVS survey are met. Once the initial IVS survey MQOs have been met, the IVS survey will be complete and the system and operators verified for field data collection.

4 Data Management

The IVS construction details (IVS item description, location, depth and orientation) will be archived in digital form. The raw and processed IVS background data well as the raw and process initial IVS survey data will be archived in a suitable format and summarized in the IVS Technical Memorandum.

5 Quality Control

Quality control (QC) for this activity will be achieved through completion of the checklist presented as Attachment 1. This checklist will be filled out and signed by the Field Geophysicist(s), Project Geophysicist, and Data Processor.

The activities described in this SOP are being performed in support of QC for a static cued advanced classification survey. The MQOs for the initial IVS survey are presented in Worksheet #22 of the QAPP. The TEM TADS will not be used for field data collection until it is able to meet these MQOs or an appropriate corrective action (CA) is determined, the project team agrees to the CA, and it is successfully implemented.

6 Reporting

The IVS construction and initial survey results will be documented in an IVS Technical Memorandum. This report will document the following:

- IVS item description including type, location, depth and orientation
- Sensor system performance against the MQOs established for the initial IVS survey including response amplitude, item position, and system noise levels

Attachment 1

SOP MR-AC-05-01 Initial Cued Instrument Verification Strip (IVS) Survey QC Checklist

This checklist is to be completed by the Field Geophysicist(s) or Project Geophysicist during construction and initial survey of the IVS.

QC Step	QC Process	Yes/No	Initial of Field or Project Geophysicist
1. IVS Construction	Has an appropriate location for the IVS been selected and verified as suitable using a background geophysical survey?		
2. IVS Construction	Have appropriate IVS seed targets been selected and procured?		
3. IVS Construction	Were the target seeds buried appropriately, backfilled and marked?		
4. IVS Construction	Is the required data on the IVS construction from Section 3.2 recorded for inclusion in the IVS Technical Memorandum?		
5. Initial Cued IVS	Is the IVS data collected in accordance with Section 3.3?		
6. Initial Cued IVS	Have the MQOs for the initial IVS survey on QAPP Worksheet #22 been achieved?		

Field Geophysicist: _____ Date: _____

Project Geophysicist: _____ Date: _____

Data Processor: _____ Date: _____

Perform Cued Surveys with TEMTADS 2x2

1 Purpose

The purpose of this Standard Operating Procedure (SOP) is to identify the means and methods to be employed when performing cued surveys using a TEMTADS 2x2 (TEMTADS) advanced electromagnetic induction (EMI) sensor for target classification. Cued surveys include the collection of cued data over predetermined target locations and background locations. Cued measurements are also performed over instrument verification strip (IVS) targets for quality control (QC) purposes.

The observed signal in a cued measurement using advanced sensors is composed of 1) the EMI response of the buried target, 2) the self-signature of the sensor system, and 3) any response from the ambient environment in which the target is buried. The objective of taking background measurements is to independently measure the last two contributors to the overall EMI response. These “non-target” values can then be subtracted from the overall signal response to determine the signal response from only the unknown buried object being evaluated. For this to be successful the background measurements must be collected in an area without any buried targets and with a geology representative of that where the unknown items are located. They must also be taken throughout the survey day because environmental changes such as large changes in ambient temperature, significant changes in background moisture (morning dew evaporating, rain showers passing through, etc.), or significant changes to the sensor itself (cable replacement, new global positioning system [GPS] antenna, etc.) will cause the sensor or environmental contribution to the background reading to change.

Cued data collection involves navigating the sensor to the precise anomaly location or background location, collecting static, advanced electromagnetic sensor data at this location, and verification/validation of the collected data. If the collected data are not complete or do not the initial qualitative inspection, a second measurement will be performed. If the derived target position estimate from the sensor falls outside a predetermined threshold, the sensor will be repositioned and a second data collection event will be performed.

2 Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP. The following is a list of required equipment and materials:

2.1 Personnel and Qualifications

The following individuals will be involved in the collection of cued advanced classification data:

- Project Geophysicist
- QC Geophysicist
- Field Geophysicist(s)
- Data Processor

The qualifications of the personnel implementing this SOP are documented in the Uniform Federal Policy (UFP) Quality Assurance Project Plan, Geophysical Classification for Munitions Response (GCMR QAPP), Worksheet #7.

2.1 Equipment

- TEMTADS sensor coupled with a real-time kinematic Global Positioning System (RTK GPS) and orientation sensor.

2.2 Materials

- Pin flags (two colors, one for blind anomaly locations and the second for background locations)
- Permanent marker (prefer clicking retractable Sharpie)
- Spray paint
- Field Notebook

3 Procedures and Guidelines

3.1 Target and Background Location Marking

Targets (anomaly locations) and Background locations will be staked out according to SOP MR-AC-08-01 (Reacquisition of Subsurface Target Locations).

3.2 Collect Background Measurements

A background measurement will be collected prior to any IVS or target anomaly measurements and nominally on an hourly basis throughout the survey day. Additional background measurements will be taken if the Project Geophysicist or Field Geophysicist(s) determine that changes made to the sensor or natural environmental changes may have caused the sensor or environmental contribution to the background reading to change. Careful field notes should be made to document the reasons for extra background readings to guide the Data Processor in choosing the correct background for each cued data set.

One or more locations for background measurements will be planned at each site. The number and location of the background measurements will be influenced by the following considerations:

- The background measurements should be collected at locations that are similar to that of the production survey area with regard to geophysical noise, terrain, geology, and vegetation. If these factors change appreciably, additional background measurements, taken at a more representative location, will be required.
- The background measurements should be collected at locations devoid of buried metal objects. If a suitable object free area cannot be identified, attempts should be made to create a “clear” 2-meter (m) square area by surveying and removing all metal objects. Once cleaned, the background measurements should be re-collected in the “clear” area.
- For efficiency, background measurements should be collected in areas that are close to the survey area(s) to minimize travel time.

Prior to using a selected background location, it must be validated as being suitable by collecting a series of 5 measurements: the first centered at the location and the next four offset by $\frac{1}{2}$ sensor spacing in each cardinal direction. Significant deviation in responses between these measurements will indicate a localized source at this location, rendering it unsuitable as a background location. If this is the case this location will be removed from the list of suitable background locations.

The procedure for taking background measurements is as follows:

1. Return the sensor to one of the previously validated background measurement locations taking care to positioning the sensor as closely as possible to the initial location and orientation.
2. Collect a background measurement.

3. Compare the measured decays to previous measurements at this location. If there are significant deviations in the measured amplitudes, repeat the measurement.
4. If the deviations persist, document the environmental changes that may have led to this deviation in the field notes.

3.3 Function Test Measurements

Function test measurements (described in SOP MR-AC-01-01) will be performed in conjunction with the background measurements to confirm that all transmit and receive components of the TEMTADS sensor are operational.

3.4 Daily IVS Survey

Prior to the start and at the end of each day of data collection, measurements of the set of IVS targets will be performed. (Described in SOP MR-AC-05-01).

3.5 Cued Target Anomaly Survey

Cued investigation for target classification involves positioning the sensor and collecting static measurements over a pre-identified set of anomalies. In combination with SOPs for sensor assembly (SOP MR-AC-01-01) and Initial testing at the IVS (SOP MR-AC-05-01), a set of static data measurements are collected using the TEMTADS over each anomaly. At each anomaly the data acquisition will be performed using the steps shown in Figure 1.

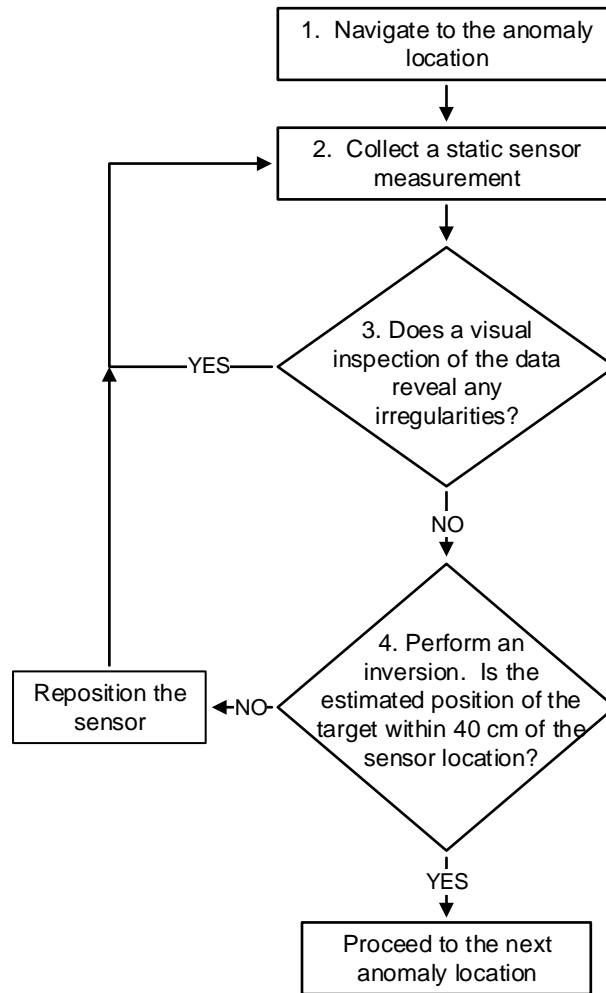


Figure 1. Procedure to Collect a Cued Target Measurement

The following is a description of each of the steps shown above:

1. **Navigate to the Anomaly Location.** Navigation to the anomaly location may be performed visually or through the use of the RTK GPS positioning system. Visual navigation requires marking the anomalies (usually with survey pin flags) in advance. Although some sensors may have the ability to direct the operator to an anomaly location based upon the geophysical signal received, the first measurement will be taken at the predetermined anomaly location as indicated by visual alignment with the pin flag or RTK GPS position relative to the predetermined position.

To implement this step the sensor will be transported to the anomaly location and the center of the sensor precisely positioned (within 5-cm) over the provided anomaly location.

If the TEMTADS 2x2 field team finds a target flag has come out of the ground, the flag will be reacquired using the RTK GPS prior to collection of cued data.

2. **Collect a set of static sensor measurements.** Initiate the collection of a set of measurements. During this measurement, care will be taken to ensure that the sensor does not move, and all external sources of electromagnetic signals (i.e. metal) are kept away from the sensor.

Any metal associated with the sensor and deployment mechanism (e.g. console, support structures) that cannot be reasonably distanced from the sensor must be kept in the same physical relation with the sensor as was maintained during background measurements.

3. **Verify the collected data.** Immediately after data acquisition, the integrity and quality of the data will be verified by the operator by inspection of the TEMTADS data collection screen to ensure that:
 - The data acquisition cycle completed properly;
 - The transmit current for each transmitter was within acceptable range (as specified in project work planning documents); and
 - The decay curves measured by each receiver coil appear reasonable (i.e., not ‘flat-lined’).
 - The IMU display shows the proper YAW prior to collection, if the reading was 777, the data packet was not captured and the collection must be repeated.
4. **Validate the collected data.** Valid inversion results require that the target is located within a 40-cm radius of the center of the sensor. The initial target horizontal position may be significantly offset from the center of the sensor for the following reasons:
 - Positioning errors in the initial detection survey
 - Imprecision in the derivation of the anomaly position from the detection survey data set
 - Imprecision in the reacquisition and flagging of the anomaly
 - Imprecision in positioning the sensor
 - The presence of multiple anomaly sources in relatively close proximity

This step includes performance of an in-field inversion and inspection of the results to validate that the estimated horizontal target location is within the 40-cm specification. After initiating the in-field inversion algorithm an estimate of the target location relative to the center of the sensor is provided. If the offset is greater than 40 cm, position the sensor over the target location estimate provided by the in-field inversion (visually or using the RTK GPS data) and repeat **Steps 2** and **3**.

This recollection should only be performed once. Assuming the repositioning was performed accurately, if the subsequent position estimate is still > 40cm from the sensor center the cause is likely to be multiple anomaly sources and additional data collection and data analysis may be required after further analysis by the QC geophysicist.

4 Data Management

4.1 Data inputs

The data inputs required for performing a cued advanced analysis data acquisition are:

- A list of target anomalies including identifier (ID) and position (X, Y)
- A list of Background locations (ID, X, Y)
- A list of IVS locations (ID, X, Y)

4.2 Data Outputs

The data outputs of the cued advanced analysis data acquisition are:

- Cued measurement data over IVS targets, background locations and target anomaly locations

- Function test measurement results
- Raw field notes (pdf images of hand written notes)
- Digital field notes (an excel or other digital format table presenting data filenames as delivered and rectified field notes [i.e., differences between delivered digital filenames and field notes are resolved])

5 Quality Control

Practical considerations limit the quality control (QC) of the cued investigation data acquisition activities to qualitative assessments. Quantitative QC and assessment of the collected data will be performed as part of SOP MR-AC-7-01 dealing with the processing of cued advanced analysis data. Results documenting QC checks performed on the dynamic data are provided as part of the delivered data package for each sortie. This documentation includes the results of the QC tests, name, and date of the review performed by the QC Geophysicist.

5.1 Measurement Quality Objectives (MQOs)

The MQOs for cued target measurements are presented in Worksheet #22 of the QAPP. Performance relative to the MQOs will be assessed during the processing of the collected data (SOP MR-AC-07-01). If it is determined during data processing that an MQO has not been met during the cued survey, a root cause analysis (RCA) will be performed and a corrective action (CA) determined. Dynamic TEMTADS data will not be used to select targets until the project team agrees on the CA and it is successfully implemented.

6 Reporting

Reporting of the activities associated with this SOP will consist of the digital copies of the field notes and data files submitted to the Data Processor.

Attachment 1
SOP MR-AC-06-01 Cued Geophysical Data Collection
Follow-on QC Checklist

Follow-on Cued Geophysical Data Collection QC Checklist

This checklist is to be completed by the QC Geophysicist daily. It should be noted that the identity of the geophysicist responsible for logging each anomaly is recorded in the anomaly data. Every time the Field Geophysicist logs cued anomaly data they are certifying that they have complied with the requirements of this SOP. The QC Geophysicist will observe the data collection process at least twice per day and will document the successful completion of this checklist in the Daily Geophysics QC Report.

QC Step	QC Process	Yes/No	Initial of QC Geophysicist
1. Qualifications	Are the same geophysical personnel being used? If not, are the qualifications of the new personnel in compliance with the requirements of Section 1.2.1?		
2. Preparation	Has the start-up and IVS QC checklist from SOP 2 been successfully completed?		
3. A.M. Field Observation	Was the a.m. field observation performed? Time: _____ Anomaly #s: _____		
4. P.M. Field Observation	Was the p.m. field observation performed? Time: _____ Anomaly #s: _____		
5. Field Documentation	Did the QC Geophysicist review the day's data collection with the Field Geophysicist and review the Field Geophysicist's notebook? Were any technical issues noted?		
6. MPC Documentation	Have the MPCs for DFW 4 from Worksheet 9 been achieved?		

QC Geophysicist: _____ Date: _____

STANDARD OPERATING PROCEDURE MR-AC-07-01
Process Cued Surveys with TEMTADS 2x2

1 Purpose

The purpose of this Standard Operating procedure (SOP) is to identify the means and methods to be employed when processing cued measurements collected using a TEMTADS advanced electromagnetic induction (EMI) sensor for target classification. Cued surveys include the collection of cued data over predetermined target locations and background locations. Cued measurements are also performed over instrument verification strip (IVS) targets for quality control (QC) purposes. This SOP details the steps required to verify the quality of these measurements, process these measurements to derive features related to the physical characteristic of the target, and use these features to classify the targets.

The detection objectives decision metrics are identified in the project-specific Uniform Federal Policy (UFP) Geophysical Classification for Munitions Response Quality Assurance Project Plan (GCMR-QAPP), hereafter referred to as the QAPP.

2 Personnel, Equipment and Materials

This section describes the personnel and equipment required to implement this SOP.

2.1 Personnel and Qualifications

The following individuals will be involved in the processing of cued TEMTADS data for advanced analysis:

- Project Geophysicist
- QC Geophysicist
- Field Geophysicist(s)
- Data Processor

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #7.

2.2 Equipment

The only required equipment is a data processing computer suitable for and equipped to run the processes provided in the UX-Advanced module of Geosoft's Oasis Montaj geophysical processing environment.

3 Procedures and Guidelines

3.1 Processing of Cued TEMTADS Data

The processing of dynamic TEMTADS data is achieved in the following steps:

1. Data conversion and import
2. QC data processing
3. Production TEMTADS data processing

3.1.1 Data Conversion and Import

The raw instrument data files (*.TEM) are converted to ASCII *.CSV file for QC and production data processing. The data are then imported into Geosoft's UXAnalyze-Advanced (UXAA) purpose built processing environment. This process results in three separate databases that contain:

- Target anomaly measurement data
- Background measurement data
- Target list

The cued measurements from the TEMTADS go into the target anomaly or background databases and the Target list is where the derived feature and classification information for each target are summarized. Once imported the data are inspected and assessed against the measurement quality objectives (MQOs) provided in QAPP WS 22

3.1.2 QC Data Processing

During the course of the cued survey, QC measurements are performed on a routine basis to verify the operation of the sensor and associated components. These tests are comprised of function tests (described in SOP MR-AC-01-01) and cued measurements at the instrument verification strip (IVS). The successful completion of these tests on a daily basis is required to validate the survey data collected on that day. The processing of QC data involves analysis of the sensor function test and IVS data to ensure that MQOs are being achieved for each sensor being used for data collection.

Processed sensor function test data shall include the following outputs:

- Background corrected sensor response values
- Sensor function test tracking sheet (*.xlsm format)
- Raw instrument files

Processed IVS data shall include the following outputs:

- IVS Cued data tracking sheet (*.xlsx format)
- Processed IVS data in Geosoft Database (*.GDB) and ASCII (*.XYZ) formats
- Raw instrument files

QC tracking sheets will be used to monitor the ongoing sensor function and IVS results for each TEMTADS system. A QC report will be included with each QC data delivery. IVS seed item measurements will be tabulated and compared against the initial seed item measurements.

QC data will be delivered by date in a QC directory on the FTP site. The raw data directory shall contain either the original raw instrument files as downloaded from the instrument. The processed data directory shall contain the final Geosoft data files.

3.2 Background Corrections

Background corrections are used to remove the self signature of the TEMTADS system and the soil response from the measured anomaly data. Background measurements are taken at locations selected from the detection survey data set. Prior to utilizing these locations for background measurements, they need to be validated to be devoid of metal. Additionally each background measurement needs to be validated as suitable prior to using it for background correction of the target measurement data.

3.2.1 Background Location Validation

Each background location is validated by comparing a set of 5 measurements taken at the intended location: one measurement at the location and one more with the sensor offset by $\frac{1}{2}$ sensor spacing in each cardinal direction. Next, the forward model of the most challenging project-specific target of interest / depth scenario is added to the center background measurement and the background is validated by separately subtracting each of the 4 offset backgrounds and performing a library match to the target of interest. The background location is considered valid if the library match from all 4 offsets exceeds 0.9. These images will be saved and presented in a background summary report.

3.2.2 Background Measurement Validation

Individual background measurements must be validated prior to their use for background corrections. Background measurements will be compared to the initial background validation measurement, and will be qualitatively validated using the same decay plot utility. These images will be saved and presented in a background summary report. Invalid measurements will be removed from background database to ensure that they are not used.

3.2.3 Background Corrections

Background corrections are applied using a purpose built tool in UXa that automatically finds the closest background (chronologically and spatially) and will only apply the background corrections that were collected within a preset time limit relative to the target measurement. This preset time limit will be set to 2 hours. The background corrected data are stored in the channel "UXa_Data_Lev". This is the data channel that is submitted to the inversion processes to derive target features. This data channel will not be populated for those target measurements that do not have a suitable background measurement within the 2 hour time limit.

3.3 Target Feature Estimation

After background corrections are applied, intrinsic and extrinsic features are estimated for the target anomalies as well as the daily QC measurements collected at the IVS.

Single target and multi-target inversion routines in UXa-Advanced are used to determine the parameters of a target (single-target inversion), or constellations of targets (multi-target inversion), that would produce responses that closely match the observed responses. These parameters include extrinsic parameters (location and orientation) as well as the intrinsic parameters (principal axis polarizabilities) related to the object size shape and composition. The intrinsic parameters, otherwise known as betas (β) are used for classification.

As the names suggest, the single-target inversion solves for a single target and the multi-target inversion posits multiple targets. The multi-source solver not only presupposes multiple sources, it will also produce a number of candidate ‘realizations’ of targets. Each candidate realization proposes a configuration of targets whose modeled response reasonably fits the observed data. For example, one candidate realization may have three targets, while a second candidate realization for the same measurement may have two or four targets. This process reflects the fact that, with an unknown number of potential targets of difference sizes and shapes, a number of different models can closely match the observed data. A separate fit coherence value is derived for each candidate realization as well as for the single solver.

3.3.1 Production Data QC

The QC of the production cued data requires assessment of the modeled data to ensure that project-specific MQOs are being achieved in each measurement acquired. In order to validate each measurement, intrinsic and extrinsic parameters are extracted from the datasets and tabulated in a QC tracking sheet which automatically flags measurements in which the MQOs are not met. This maintains the chronologic integrity of the cued data and prevents the out-of-specification data from being used for classification. Parameters tabulated from the modeled data are as follows:

- Transmit (Tx) current within limits
- Global positioning system (GPS) fix quality
- Valid inertial measurement unit (IMU) data
- EMI response signal not saturated
- Array-Flag offset
- Array-Fit offset
- Single-solver Inversion fit coherency
- Multi-solver Inversion fit coherency
- Signal amplitude

Model results will only be used for classification if they pass the MQOs identified to confirm that they support classification (QAPP WS 22).

3.4 Classification

Classification of targets will be based upon objective, numeric criteria. Using these criteria, a prioritized list is created with high likelihood target of interest (TOI) placed at the top of the dig list (just after digs classified as “training data” and “can’t analyze”) and high likelihood non-TOI placed at the bottom of the list. The primary method for classification will be library matching, supplemented by cluster analysis and feature space analysis.

3.4.1 Site Specific Munitions Library

A site specific library of β s for candidate munitions items identified in the conceptual site model (CSM) will be used for classification. Entries in existing libraries will be confirmed as representative (i.e. the same caliber, model and configuration) of the munitions items presented in the table by a qualified unexploded

ordnance (UXO) Technician. Intrinsic parameters for items listed in the CSM not confirmed to be in the existing library will be derived from test measurements prior to the start of the classification process.

3.4.2 Library Matching

Classification is based primarily on the goodness of fit metric (values from 0.0 to 1.0) generated by UXA during a comparison of the β values estimated for each surveyed target and the β values in the munitions library developed for the project. This comparison is performed via the library match utility in UXA. The goodness of fit metric is a measure of the fit correlation between a target and the library entry that best fits that target, with higher values indicating a better fit between the target and the corresponding item in the library. The library fit analysis matches the following four combinations of β s to those of the candidate library TOIs:

- $\beta_1, \beta_1/\beta_2, \beta_1/\beta_3$
- $\beta_1, \beta_1/\beta_2$
- $\beta_1/\beta_2, \beta_1/\beta_3$
- β_1

The confidence metrics for each fit combination are averaged to derive a 'decision metric'.

This library matching process is performed for each single-solver model and every target in each of the multi-source solver candidate realization models. For each flag position, the best library fit from the single-solver and multi-solver targets is used as the decision metric. This decision metric is used to rank and classify the target list. Values below the analysts threshold (nominally 0.8) are considered non-TOI.

A set of training digs are identified by the analyst. The intrusive investigation results of these digs as well as decision metrics derived for other known TOI (IVS and Seed items) are used to finalize the analyst threshold.

3.4.3 Cluster Analysis/Feature space Analysis

Cluster analyses are performed whereby the clusters of anomalies with similar β signatures are identified using the self match utility in UXA. For each identified cluster, a representative sample is intrusively investigated as part of the training data. If the intrusive investigation identifies a hazardous item, a representative signature is placed in the site specific library and the matching process will be repeated to ensure that all similar items are classified as TOI.

Individual items that do not match any library items but have β s that indicate a large, axially symmetric, thick-walled object are identified and investigated as part of the training data and added to the library if they are identified as TOI.

4 Data Management

4.1 Data inputs

The data inputs required for performing a cued advanced analysis data acquisition are:

- A list of target anomalies including identifier (ID) and position (X, Y)
- A list of Background locations (ID, X, Y)
- A list of IVS locations (ID, X, Y)
- TEMTADS Measurement data including those for Target anomalies, daily IVS, Backgrounds, and Function tests
- Digital field notes for all data collection activities
- Site specific library signatures and/or test stand measurements of intended site specific library items

4.2 Data Outputs

The data outputs of the cued advanced analysis data processing for each delivered survey unit (contiguous subset of the survey site) are:

- QC report including documenting performance relative to QAPP WS 22 for:
 - IVS results
 - Function Test Results
 - Background measurements
 - Target Anomaly Measurements
- Prioritized target list
- Target classification report
- Revised validation plan
- Target Measurement Data, Background Measurement Data, and Target Feature Databases
- Supporting documents for classification (PDF images)

5 Quality Control

The data processing log and a QC report will contain the results of the QC checks performed during cued surveys. The results and processing log will be provided as part of the data package delivered with each sortie. The QC report will be delivered in accordance with the frequency listed in the QAPP.

5.1 Measurement Quality Objectives (MQOs)

The MQOs for cued target measurements are presented in WS 22 of the QAPP. Performance relative to the MQOs will be assessed during the processing of the collected data. Cued data will not be used to classify targets until these MQOs are met or until the project team agrees on modifications to these MQOs.

6 Reporting

Reporting of the activities associated with this SOP will consist of:

- QC Report - detailing the daily system performance against the MQOs identified on QAPP WS 22 (including MQOs for daily IVS and Function Test performance as well as for individual measurement metrics).

- Classification Report – detailing specific approach to classification including final library make-up, cut-off threshold, cluster analysis approach and results, and feature space analysis approach and results

Cued datasets will be assembled into a final delivery package that includes the following:

- Raw instrument *.TEM files per grid or survey area
- Pre-processed ASCII *.CSV files per grid or survey area
- QC report summarizing daily QC results (Function tests and IVS tests)
- QC data by date as detailed in section **Error! Reference source not found.**
- Processed cued data per grid or survey area in Geosoft Database (*.GDB) format
- Final target list per grid or survey area in Geosoft Database (*.GDB) format
- Decision plots per grid or survey area (*.MAP and *.PDF format)

Processed cued data will be delivered in the final data directory on the FTP site.

Reacquisition of Targets Prior to Intrusive Investigations

1 Purpose

The purpose of this SOP is to identify the means and methods to be employed when reacquiring target locations prior to intrusive investigations. This SOP specifically addresses targets derived from analysis of cued interrogation data collected using advanced electromagnetic induction (EMI) sensors (e.g. TEMTADS 2x2).

2 Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP. The following is a list of required equipment and materials:

Personnel:

- Field geophysicists or other staff experienced in operation of a Real Time Kinematic (RTK) Global Positioning System (GPS)
- Professional Land Surveyor (PLS) and field support staff
- UXO personnel (1 UXO technician per reacquisition team)

Note: When reacquisition is required in areas where use of RTK GPS may not be reliable (e.g. wooded sites), reacquisition will be performed by a licensed PLS in good standing with the state where field work will be performed. When reacquisition can be performed using RTK GPS, CH2M HILL will perform reacquisition, unless otherwise noted in the project work planning documents.

Equipment and Materials:

- RTK GPS or Total Station, as appropriate
- Survey pole (bi-pole or monopole) with level bubbles in proper working condition
- List of targets to reacquire
- Non-metallic vinyl-stem flags
- Permanent marker (retractable Sharpie is optimal)
- Hip or waist tool belt to hold flags, pens, extra GPS batteries
- Tool to loosen hard ground (awl or screwdriver) if allowed by SUXOS (optional)

2.1 Personnel and Qualification

The following individuals will be involved in the reacquisition of targets prior to and during intrusive activities:

- Field Geophysicist(s) or other staff experienced in operation of RTK GPS will be responsible for uploading targets to RTK GPS data collector, operation and maintenance of field equipment, reacquisition of targets and placement of flags, and daily downloading and quality control (QC) checks.
- UXO Personnel will be responsible for overall daily site access and safety aspects of the project, compiling subcontractor health and safety documents (as appropriate), conducting daily safety briefings and performing subsurface anomaly avoidance during placement of flags or other activities that may involve ground disturbance.

- Professional Land Surveyor field staff will be responsible for operation of total station (or robotic total station) equipment, uploading targets to instrument data collector, operation and maintenance of field equipment, reacquisition of targets and placement of flags, and daily downloading and QC checks.
- Data Processing Geophysicist(s) will be responsible for providing target lists to the field team for reacquisition. The Data Processing Geophysicists will also be responsible for verification of the field efforts as well as performing additional QC checks on daily downloaded RTK GPS or total station instrument files.

3 Procedures and Guidelines

3.1 Target Reacquisition Prior to Intrusive Activities

The Data Processing Geophysicist will be responsible for delivery of current target lists (in Microsoft Comma Separated Variable [CSV] format) to the reacquisition field team leader (CH2M HILL or PLS). These lists will be comprised of the actual target location (i.e. will not be offset by any safety factor) and will be provided in the project-specific projection, datum, and units.

The field team leader will open the supplied data file and compare the number of listed targets versus the quantity stipulated by the Data Processing Geophysicist. If a discrepancy is noted, the field team leader will resolve the discrepancy with the Data Processing Geophysicist prior to stakeout of targets.

The targets will be loaded into the instrument data collector. Targets will be loaded such that the Target ID provided in the supplied list is assigned to the recorded measurement at the time of flag placement.

The target location will be marked with paint and a flag will be placed at a predetermined distance north of the anomaly (this can be easily measured using a ruler or stick cut to the required offset distance). The field teams will write the Target ID legibly on the flag in marker. If a mistake is made during writing the IDs, a new flag will be used and the erroneous flag discarded (as opposed to crossing or scribbling out incorrect IDs).

The 'as-staked' location of the flag will be surveyed in and recorded for QC review. Once the 'as-staked' flag location is stored, the target will be removed from the active reacquisition list to avoid accidental navigation to the wrong target.

3.2 Recording Item Locations during Intrusive Activities

The reacquisition field team accompanies the dig teams and records the precise in-situ locations of the dig findings. Each recorded measurement shall have the full Target ID and a letter for each object uncovered per dig location. If multiple subsurface items are found at a dig location, each item will be recorded, and the Target IDs will be appended with a sequential letter, starting with "A."

3.3 Subsurface Anomaly Avoidance

A UXO technician will be assigned to each reacquisition teams. UXO personnel will perform subsurface anomaly avoidance at each intended flag location using handheld analog geophysical instruments (which will undergo daily function checks).

If a subsurface anomaly prevents safe placement of the flag at the supplied target location (i.e. the offset location from the geophysical anomaly location), the field team leader will make note of the

condition, place the flag as close as safely possible to the supplied location, record the measurement, and annotate the finding in the daily field notes provided to the Data Processing Geophysicist. The Data Processing Geophysicist and field team leader will evaluate whether the “as-staked” location is sufficient for placement of the TEMTADS 2x2 during follow-up cued surveys or if a new offset distance and/or direction is warranted. In any case, the Data Processing Geophysicist and reacquisition field team leader will inform the TEMTADS 2x2 cued survey team of the deviation from the offset protocol established for the project in order to facilitate proper position and alignment of the TEMTADS 2x2 sensor during the cued interrogation survey.

4 Quality Control

4.1 Daily Instrument Position Accuracy Check

At the beginning of each day, the instrument used for reacquisition will undergo a field QC check for positional accuracy. A known, previously-established point (e.g. benchmark, control point) shall be loaded into the instrument data collector, and a daily measurement shall be performed at this point. The measured coordinates will be compared to the previously-established coordinates. The Measurement Quality Objective (MQO) is the measured coordinates are within 4 inches (10 centimeters) of the known coordinates.

4.2 Data Verification

After downloading and prior to submitting the instrument data collector files, the reacquisition field team leader will be responsible for comparing the number of recorded measurements to the daily field notes in order to check for completeness of the records. Discrepancies will be resolved by the field teams (CH2M HILL, PLS, UXO personnel) prior to submittal of the information to the Data Processing Geophysicist. Necessary adjustments to file names, Target IDs, or other information will be performed prior to submittal of the information to the Data Processing Geophysicist.

4.3 Comparison of Recorded Flag Locations to Supplied Target Coordinates

During reacquisition in advance of intrusive investigations, daily QC checks will be performed on the recorded flag locations by comparing the measured flag locations to the target locations supplied by the Data Processing Geophysicist. Below is an example of the comparison (note that the offset is accounted for in the calculation of the x and y errors):

TARGET_ID	FIT_X	FIT_Y	Safety Offset	Flag_X	Flag_Y	X err (m)	Y err (m)	Dist err (m)
1220038_001_01	704935.21	3914585.22	0.50	704935.31	3914585.73	0.10	0.01	0.10
1320065_001_04	704965.77	3914588.12	0.50	704965.82	3914588.61	0.05	-0.01	0.05
1420101_001_02	705012.23	3914584.66	0.50	705012.30	3914585.16	0.07	0.00	0.07

The MQO for this check is 4 inches (10 centimeters). If the difference between the measured flag location and supplied target is >4 inches (10 centimeters), the target will be reacquired in the field and resolve prior to conducting the intrusive investigation.

5 Reporting

Instrument data collector files will be downloaded daily and submitted by the reacquisition field team leader (CH2M HILL or PLS) to the Data Processing Geophysicist via the established communication pathways (email, Share Point, File Transfer Protocol). Information will not be submitted to the Data Processing Geophysicist until discrepancies in Target IDs, quantities, or other relevant information is resolved by the field teams. Daily field notes shall be provided with the data delivery package.

Surface Sweep Quality Control Seeding

1 Purpose

The purpose of this SOP is to identify the methods to be employed when emplacing surface QC seeds in the area to be subjected to a surface sweep. The purpose of emplacing QC seeds is to serve as a verification of the surface sweep coverage. To achieve this the Unexploded Ordnance Quality Control Specialist (UXOQCS) places controlled “seed” objects in the production area without the knowledge of the locations of the seeds by members of the surface sweep team. The seeding program serves as a continuous indicator of the surface sweep coverage and compliance with the requirements for items being removed from the surface.

2 Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP. The following is a list of required equipment and materials:

- Metallic objects meeting the size criteria established for the project.
- Indelible markers and/or weatherproof labels.

2.1 Personnel and Qualification

The following individuals will be involved in the Surface Sweep QC Seeding:

- UXOQCS

3 Procedures and Guidelines

This SOP constitutes the surface sweep seed plan. The following procedures should be followed.

3.1 Seed Emplacement

Table 1 provides the parameters for the surface sweep seeds.

Table 1. Surface Sweep Seed Parameters

Parameter	Implementation
Number of seeds	Seeds will be placed in accordance with the QC seeding checklist.
Type of seeds	Metallic objects meeting the size criteria for the specific project.
Seed Labeling	Seeds should either be directly labeled with an indelible marker or a weather proof label attached to the item. Labels should be of a type that does not call particular attention to the location of the seed.
Location Measurement	The UXOQCS must use a method of recording the locations of the seeds with enough accuracy that, should a seed not be returned after the area has been swept, they can return to the location to verify that the item was not picked up.

4 Documentation

The UXOQCS must record the locations of the seed items, and the type of item along with its unique identifier, in QC logbook or digital record. This information must not be shared with operational personnel.

5 Quality Control

Surface sweep area seeding is performed by the UXOQCS prior to a surface sweep being performed in any particular unit (e.g., grid). Therefore, this is a preparatory QC process and is guided by the Preparatory QC Checklist in Attachment 1. If control of the seed information is compromised this should be evaluated and consideration should be given to removal and re-emplacement of the seeds.

5.1 Measurement Quality Objective (MQOs)

The MQOs for detection of surface seeds are presented in Worksheet #12 of the Quality Assurance Project Plan (QAPP).

5.2 Reporting

The UXOQCS should report the surface sweep seeding activities and results from the operations (i.e., whether the seeds were found and returned).

Attachment 1**SOP MR-AC-01-01 Preparatory Surface Sweep Area Seeding QC Checklist**

This checklist is to be completed by the QC Geophysicist when performing production area seeding.

QC Step	QC Process and Guidance Reference	Yes/No	UXOQCS Initials
1. Determine seed parameters	Number of seeds: (A) Anticipated Production Rate for Team: _____ acres/day (B) Total Personnel on Team: _____ (C) Quantity of targets to be placed per acre: $B * 2/A =$ _____		
2. Labels	Are the seed labeled as required by this SOP?		
3. Documentation	Are the emplacement data recorded as required by this SOP?		
4. Data management and reporting	Is the seeding information in location kept unavailable to the production surface sweep personnel?		
5. MPC Documentation	Have the MPCs for from Worksheet 12 been achieved for the surface sweep seeds?		

UXOQCS: _____ Date: _____

Production Area Quality Control Seeding

1 Purpose

The purpose of this SOP is to identify the methods to be employed when emplacing quality control (QC) seeds in the production area for an advanced electromagnetic induction (EMI) classification project. The purpose of emplacing QC seeds is to serve as controlled tests and demonstrations of the capabilities of the geophysical classification program on the actual site and under the actual conditions of the production geophysical processes. To achieve this the controlled “seed” objects are buried in the production area without the knowledge of the production geophysicists. The quality of the data collected on the controlled seeds is, therefore, indicative of the quality of the data being collected in general. Thus, the seeding program serves as a continuous indicator of the adequacy of the production geophysical program. As such, adequate performance on the seeds that are not known to be seeds to the production geophysics team (known as “blind” seeds) is a strong indicator that overall production data collection and analysis quality is also adequate.

2 Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP. The following is a list of required equipment and materials:

- Appropriate inert munitions and schedule 80 small ISOs (small ISO80) to serve as seeds. Figure 1 shows an example of this item from the McMaster-Carr Catalog.
- Hand tools including shovels, pick axes, breaker bars, etc. to bury the seeds. Excavators may be used in the event that large and deep MEC are expected to be found onsite as indicated by the CSM in the Uniform Federal Policy (UFP) Quality Assurance Project Plan, Geophysical Classification for Munitions Response (GCMR QAPP) Worksheet #10.

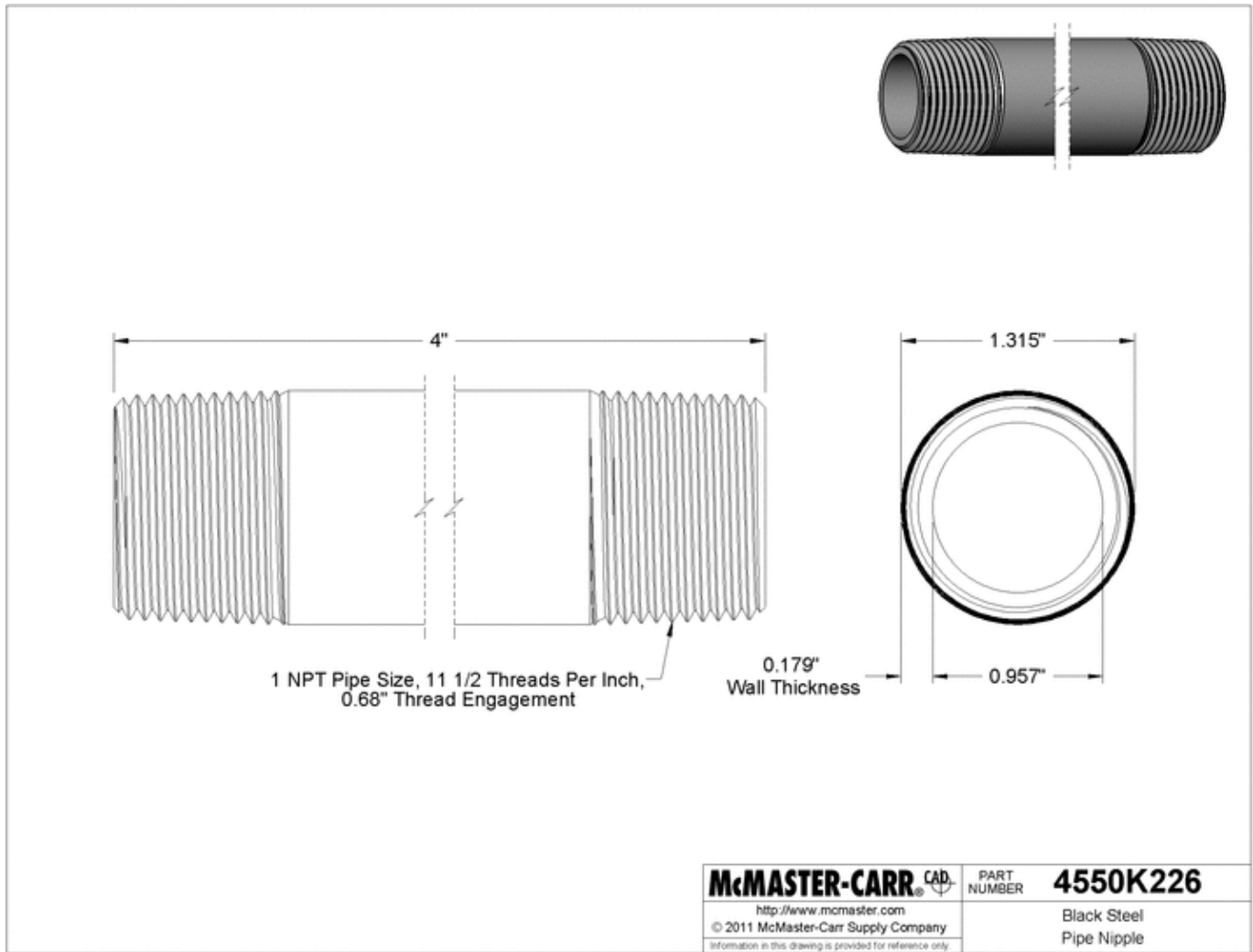


Figure 1. Small Industry Standard Object – Schedule 80

2.1 Personnel and Qualifications

The following individuals will be involved in the QC seeding:

- QC Geophysicist
- Unexploded Ordnance Quality Control Specialist (UXOQCS) or his designee (a UXO Qualified Technician)
- Professional Land Surveyor

The qualifications of the personnel implementing this SOP are documented in the UFP-GCMR QAPP, Worksheet #7.

3 Procedures and Guidelines

The following procedures should be followed.

3.1 Anomaly Avoidance

Important note: The emplacement of QC seeds requires performing intrusive excavation in areas that are likely to contain munitions and explosives of concern (MEC). Therefore, all activities involving digging into MEC survey areas is required by DoD guidance to be supported by an Unexploded Ordnance (UXO) Anomaly Avoidance Plan. Development and implementation of this plan is not covered in this SOP. However, it is the responsibility of the QC Geophysicist directing the emplacement of the seeds to ensure that operations are not performed within areas potentially containing MEC without appropriate UXO escorts operating under a UXO Anomaly Avoidance Plan developed in accordance with the requirements of Department of Defense Manual 6055.9-M, Volume 7, *DoD Ammunition and Explosives Safety Standards: Criteria for Unexploded Ordnance, Munitions Response, Waste Military Munitions, and Material Potentially Presenting an Explosive Hazard* (August 4, 2010), Section V7.E3.4.3 or other applicable guidance developed by the military component managing the MR geophysical classification project.

3.2 Seed Emplacement

The purpose of the MR geophysical classification project is to reconstruct the physical parameters of the buried targets including the target location, depth, inclination, azimuth, and size. Therefore it is critical for the success of the study to survey, as accurately and precisely as possible, the **actual locations** of the buried seeds. To that end, the emplacement team should dig in a fashion to minimize seed migration (e.g., settling) after burial.

The parameters identified in Table 1 should be used to develop the seed burial parameters. The intended burial locations are given to 1-cm precision, with the intended depths to 5-cm precision and the intended inclinations and azimuths to 10-degree precision. The locations and placement of the final burials should be surveyed relative to the cm-level control points.

Table 1. Production Seed Burial Parameters

Parameter	Implementation
Number of seeds	Sufficient to ensure encountering at least 1 blind seed/work day. Calculate the average number of targets that will be subjected to data collection during a full work day and divide the total number of targets by the average daily number. Multiply this resulting number by 1.2 to achieve the total number of blind seeds to be emplaced. Record this number on the Preparatory QC Checklist in Attachment 1 to this SOP.
Type of seeds	Determine the type of seeds to be used based on the CSM for the project site. It is noted that this is a physics-based approach and the results achieved using only small ISOs buried at a standard depth is equally effective as using a variety of ISOs buried at various depths. However, using a more complex mix of seed size and depth may be beneficial for demonstrating the full capabilities of the geophysical classification program and consideration should be given to including some larger and deeper seeds to increase stakeholder confidence. Record the type of seeds to be used on the Preparatory QC Checklist in Attachment 1 to this SOP.
Location and depth of seeds	Randomly placed throughout the production work area to achieve the likely encountering of at least one seed/day by the production geophysics team. Use GPS to record the location and depth of each seed in a separate QC data file that is not available to the production geophysics team. See additional details in this section below.

The parameters developed should be viewed as a ***guide*** for seed emplacement. The emplacement team may allow small deviations from the intended burial parameters recorded on the QC Checklist in Attachment 1 due to changes caused by actual field conditions (for example, if the UXO escorts will not allow intrusive activities at the planned location due to MEC hazards). Variation is acceptable as long as the exact burial data is recorded.

After emplacing a seed in the ground, but before covering it with dirt, the following information should be carefully recorded and maintained in a QC data file that is not available to the production geophysics team:

- The x, y, and z coordinates for the center of the seed, with coordinates reported in the project-specific coordinate system, datum, and units;
- The depth of the seed, measured as the vertical distance from the bottom of a straight edge placed across the opening of the hole down to the center of the seed; and,
- A photograph of the seed, showing its serial number. A ruler or similar scale should also be included in the photograph.

For each seed, the emplacement team should also:

- Ensure the seed is marked with blue paint to identify it as inert;
- Replace any ambient metallic items that were found in the hole to simulate the natural local environment;
- Replace dirt in the hole as completely and naturally as possible;
- Level the burial location; and,

- Replace the grass plug over the burial location (if applicable).

4 Data Management

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 Input Data Required

The production area seed plan (developed in accordance with this SOP and recorded on the QC Checklist in Attachment 1) which contains the initial parameters for the seeds is required for implementation of this SOP.

4.2 Output Data

The output data from this SOP are:

1. The QC data files recording the data on each seed (type, location, depth, etc.) as required by Section 3.2 above.
2. The Production Area Seed Report. This report consists of a brief narrative describing the seed emplacement, the ideal seed placement parameters, the actual QC data files from #1 above and a discussion of significant deviations from the seed plan. The bulk of the report consists of a seed location table that includes the “as emplaced” identity, location, depth, and orientation of each of the emplaced seeds accompanied by a photograph of the item in the ground before being covered.

5 Quality Control

Production area seeding is performed once by the QC Geophysicist prior to production area geophysics. Therefore, this is a preparatory QC process and is guided by the Preparatory QC Checklist in Attachment 1. This activity is performed solely by the QC Geophysicist or a QC designee (who has no involvement in the production data collection or processing) with the assistance of UXO specialists as safety escorts and the data on the production areas seeds should be restricted and not made available to the production geophysics team. If control of the seed files is compromised this should be evaluated and consideration should be given to removal and re-emplacement of the seeds.

5.1 Measurement Performance Criteria (MPCs)

The MPCs for this activity are presented in Worksheet 10 of the QAPP.

5.2 Reporting

The QC Geophysicist should compile the Production Area Seed Report as described in Section 4.2 above. This report can be shared with the DoD managers if they desire to receive it. Otherwise, it will be password protected and maintained by the QC Geophysicist to be included in the Project Report as an attachment.

Attachment 1**SOP MR-AC-02-01 Preparatory Production Area Seeding QC Checklist**

This checklist is to be completed by the QC Geophysicist when performing production area seeding.

QC Step	QC Process and Guidance Reference	Yes/No	Initial of QC Geophysicist and UXO Technician
1. Determine seed parameters	Number of seeds: Average number of targets daily: _____ Total targets ÷ average daily X 1.2: _____ The number above is the minimum number of seeds.		
2. Determine seed parameters	Type of seeds: Are small ISOs appropriate for use: _____ If not, develop alternative seeds based on CSM and list here: _____ _____		
3. Safety	Is a qualified UXO escort assigned and are they operating under an approved UXO Avoidance Plan (see Section 3.1)?		
4. Documentation	Are the emplacement data recorded as required by Sections 3.2 and 4.2?		
5. Data management and reporting	Is the Production Area Seed Report prepared and maintained in a password protected file available only to the QC Geophysicist?		
6. MPC Documentation	Have the MPCs for seeding from Worksheet 10 been achieved?		

UXO Technician: _____ Date: _____

QC Geophysicist: _____ Date: _____

Surface Clearance

1 Purpose

The purpose of this Standard Operating Procedure (SOP) is to identify the methods to be employed when performing a surface clearance (also known as a surface sweep) for Munitions and Explosives of Concern (MEC). This SOP is to be used during munitions response (MR) projects directly performed by CH2M HILL Unexploded Ordnance (UXO) Technicians engaged in surface clearance. A surface clearance is a visual clearance of MEC, Material Potentially Presenting an Explosive Hazard (MPPEH) and Munitions Debris (MD) from a specified geographic surface by qualified UXO Technicians. Surface clearances may also be aided by handheld detectors in vegetated areas where visibility of the surface is reduced. These clearances are frequently performed in advance of digital geophysical mapping surveys to reduce the number of resultant target anomalies. They also serve to reduce the risks associated with explosive hazards on the ground surface. Surface clearances frequently employ a grid-based approach to define the boundary of the geographic area to be cleared. MEC and MPPEH items that are deemed unacceptable to move are flagged for subsequent disposal operations. Extreme care will be taken during surface clearances to avoid moving or otherwise disturbing items which are assumed to be MEC or MPPEH until determined acceptable or safe to move by UXO Technicians Level II or above. MEC, MPPEH and MD items that are acceptable to move are usually collected and placed in a designated corner of the grid to await further evaluation and processing. Surface clearances are typically coordinated by a Senior UXO Supervisor (SUXOS) and conducted by a UXO Tech Level III UXO Team Leader who leads a team of UXO Tech Level IIs and Is. CH2M HILL teams will consist of a minimum of two people. A UXO Quality Control Specialist (UXOQCS) will perform an independent evaluation of the surface clearance in accordance with the Quality Assurance Project Plan (QAPP). All will be supported by the observations and advice provided by the UXO Safety Officer (UXOSO) using the QAPP and Site Specific Health & Safety Plan.

This SOP does not include processes and requirements associated with explosive demolition of MEC or the evaluation processes related to MPPEH. It is also intended that the procedures included herein apply specifically to land-based MR operations. There are many references that guide the general requirements within this SOP. Due to the inherent and hazardous nature of military munitions, most of these references are issued under the cognizance of the U.S. Department of Defense through administration of its Military Munitions Response Program (MMRP) and the Component Services that execute the MMRP. While some of these references will be cited later in this SOP, it is the obligation of all CH2M HILL MR personnel to stay apprised of such requirements and their revisions. Additionally, surface clearance and subsurface excavation of MEC operations conducted for Department of Defense (DoD) projects will strictly comply with all requirements articulated in approved Explosives Site Plans (ESP) or Explosives Safety Submissions (ESS) and Project Managers will ensure ESPs/ESSs are amended appropriately whenever necessary.

2 Definitions

Note: Definitions other than those provided below may apply for MR work performed outside U.S. jurisdictions. Check contractual references to ensure correct definitions are applied.

- **Material Documented as Safe (MDAS).** Material that has been assessed and documented as not presenting an explosive hazard and for which the chain-of-custody has been established and maintained. This material is no longer considered MPPEH per DoD Instruction 4140.62 (see References).

- **Material Documented as an Explosive Hazard (MDEH).** MPPEH that cannot be documented as MDAS that has been assessed and documented as to the maximum explosive hazards the material is known or suspected to present, and for which the chain-of custody has been established and maintained. This material is no longer considered to be MPPEH per DoD Instruction 4140.62 (see References). (The MDEH characterization only addresses the explosives safety status of the material.)
- **Munitions and Explosives of Concern (MEC).** This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks means: (A) Unexploded ordnance (UXO), as defined in 10 U.S.C. 101(e)(5); (B) Discarded military munitions (DMM), as defined in 10 U.S.C. 2710(e)(2); or (C) Munitions constituents (e.g., TNT, RDX), as defined in 10 U.S.C. 2710(e)(3), present in high enough concentrations to pose an explosive hazard.
- **Material Potentially Presenting an Explosive Hazard (MPPEH).** Material owned or controlled by the Department of Defense that, prior to determination of its explosives safety status, potentially contains explosives or munitions (e.g., munitions containers and packaging material; munitions debris remaining after munitions use, demilitarization, or disposal; and range-related debris) or potentially contains a high enough concentration of explosives that the material presents an explosive hazard (e.g., equipment, drainage systems, holding tanks, piping, or ventilation ducts that were associated with munitions production, demilitarization, or disposal operations). Excluded from MPPEH are munitions within the DoD-established munitions management system and other items that may present explosion hazards (e.g., gasoline cans and compressed gas cylinders) that are not munitions and are not intended for use as munitions per DoD Instruction 4140.62 (see References).
- **Munitions Debris (MD).** A military munition or components thereof that do not contain explosives or pyrotechnics. Examples include practice munitions without spotting charges, inert training munitions, expended ejection munitions, and fragments of exploded/destroyed military munitions that do not contain explosives or pyrotechnics.

3 Personnel, Equipment and Materials

3.1 Personnel and Qualifications

The following individuals will be involved in the Surface Clearance:

- **MR Operations Director:** Ensures CH2M HILL MR personnel shall be qualified in accordance with DDESB Technical Paper (TP) 18, Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel and are certified to perform the job assigned and that certifications are current. Prior to MR operations, The MR Operations Director will verify training, medical qualification statements by physicians, and conformance to substance abuse testing and reporting programs. The MR Operations Director implements a personnel qualification and certification program for MR personnel consistent with the requirements for UXO personnel at various levels of responsibility as specified in DDESB TP 18.
- **Project Manager (PM):** Provides the project leadership and direction to ensure that the project is performed within the scope, schedule and budget, ensures quality, risk management, safety and contract compliance. The PM will ensure that site-specific work plans, safety plans, and/or SOPs that adequately address site-specific hazards and control measures are in place prior to the start of work.

- **MR HSSE Manager:** Assists and advises the MR and project staff to plan, staff, and execute the MR safety program. Audits and evaluates MR field projects and safety programs to verify that HSSE requirements and practices are implemented and effective.
- **Senior UXO Supervisors and Unexploded Ordnance Technicians III or II:** Supervise the operational resources necessary to implement, and accomplish the procedures and requirements set forth within the Work, Health, Safety, Quality and Accident Prevention Plans of MR projects. They are required on all MR projects, and authorized to stop work at any time to prevent accidents, remedy unsafe conditions, stop an unsafe act, or question the safety of a process or procedure or observe non-conformance to this SOP and/or plans. UXO Team Leaders shall also be responsible for recording data in MRSIMS and their log books. The SUXOS shall ensure Explosives Safety Quantity Distances (ESQD) are properly determined and enforced, as well as brief MR and project-essential personnel on communications, security, emergency/medical response, evacuation, rally points using project instructions and plans. This person shall inform personnel to prevent disclosure of classified work, site observations, or information.
- **Unexploded Ordnance Quality Control Specialist (UXOQCS):** Assists with the implementation of this SOP. Reports to the Munitions Response Quality Control Manager. Monitors conformance to this SOP and Work, Health, Safety, Quality, and Accident Prevention Plans. This individual ensures that quality control processes and procedures are executed in accordance with the Quality Control Plan (QCP) and or project instructions.
- **Unexploded Ordnance Safety Officer (UXOSO) and/or UXOQCS (may be a dual-hatted position for small or unique projects when specifically approved during the Munitions Response Technical Risk Evaluation (MRTRE), is required on each project covered in the scope of this SOP and reports to the Munitions Response Health, Safety and Quality Manager):** The UXOSO provides a Daily Site Specific Tailgate Safety Briefing to include MEC, construction, industrial, environmental, and natural safety hazard awareness and provides the plan of the day. As applicable, they provide a Hazardous Materials briefing for items used, consumed, or required for this SOP. The UXOSO performs risk assessment to determine the number of visitors permitted, provides a safety briefing, and verifies training and medical surveillance qualifications of personnel.

3.2 Equipment and Materials

This section describes the equipment and materials required to implement this SOP.

- Surveyor tapes or ropes to mark sweep lanes
- Metal detector (if instrument-assisted clearance) appropriate to types of metal required to be found and removed from the surface
- Digital camera or other device capable of taking photos
- Bound logbook, tablet with digital logbook, or other means of recording results

4 Procedures and Guidelines

This SOP constitutes the surface sweep plan. The following procedures should be followed:

- Operations will be conducted during daylight hours only.
- Access to operating areas will be limited to only those personnel necessary to accomplish the specific operation.

- UXO will only be handled by qualified UXO Technicians.
- During UXO operations the minimum separation distance (MSD) between UXO and non-UXO operations is the fragmentation distance of the munition with the greatest fragmentation distance (MGFD), as stated in the Explosives Site Plan (ESP).
- All personnel will attend the daily safety briefing (tailgate safety briefing) prior to entering the operating area.
- Anyone can stop operations for an unsafe act or situation.
- Safety violations and/or unsafe acts will be immediately reported to the UXO Safety Officer (UXOSO).
- The field team will systematically sweep the area, traversing each transect, or series of transects until the area has been completely swept.
 - Sweep operations will be performed under the direct supervision of a qualified UXO Technician III.
 - The lanes may or may not be established prior to sweeping. If temporary lanes are marked prior to sweeping it will be done by a UXO technician to ensure safety.
 - If individual lanes (5 feet apart) are pre-marked then qualified UXO technicians sweep the lane (using an approved metal detector if performing an instrument-assisted sweep) until the lane has been completed.
 - If individual lanes are not premarked, the Team Leader (UXO Technician III) will assemble the team members into a sweep line and direct their movement across the survey area.
 - Team members will be spaced approximately 5 feet apart and, at the direction of the Team Leader, move through the grid on line abreast.
 - When an item is encountered, the individual team members call out "hold the line", the line will stop and the UXO Technician will inspect the object to determine if it is MEC or scrap and either pick the item up (if safe to move) or mark the item with the appropriate colored Pin Flag. The line will not move again until directed by the Team Leader.
 - When flags are used, red will demarcate a MEC item, blue will demarcate munitions debris, and green will demarcate non-munitions related scrap.
 - As the team moves forward the sweeper at the edge of the grid will use the grid stakes as one sweep lane boundary, the sweeper on the opposite end of the line will mark the limit of the sweep lane with White Pin Flags. These flags become the guide for the return sweep and define the limits of the previously cleared lane.
 - This procedure is continued until the grid is completely swept.
 - If an item requiring disposal is required, OTIEX SOP-01 will be used.

5 Documentation

The UXOQCS must record the locations of the seed items, and the type of item along with its unique identifier, in QC logbook or digital record. This information must not be shared with operational personnel.

Munitions debris located on the surface will be recorded on a per unit (i.e. grid, transect, etc.) basis and documented. The GPS coordinates for all UXO will be recorded and documented. Photographs of representative types of munitions debris and all UXO items will be taken and documented.

6 Quality Control

Surface sweep area seeding is performed by the UXOQCS prior to a surface sweep being performed in any particular unit (e.g., grid). Therefore, this is a preparatory QC process and is guided by the Preparatory QC Checklist in Attachment 1. If control of the seed information is compromised this should be evaluated and consideration should be given to removal and re-emplacement of the seeds.

6.1 Measurement Quality Objective (MQOs)

The MQOs for detection of surface seeds are presented in Worksheet #12 of the Quality Assurance Project Plan (QAPP).

6.2 Reporting

The UXOQCS should report the surface sweep seeding activities and results from the operations (i.e., whether the seeds were found and returned).

7 References

- DoD Instruction 4140.62, "Management and Disposition of Material Potentially Presenting an Explosive Hazard," November 5, 2008.
- DOD 6055.09-M, Ammunition and Explosives Safety Standards, August 2010.
- DDESB TP-18 Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel, December 2004.
- DA 385-64, Ammunition and Explosive Safety Standards, August 2008.
- DA Engineering Manual (EM) 385-1-97 Explosives, Health and Safety, September 2008.

Attachment 1**SOP MR-AC-22-01 Preparatory Surface Sweep Area Seeding QC Checklist**

This checklist is to be completed by the QC Geophysicist when performing production area seeding

QC Step	QC Process and Guidance Reference	Yes/No	Initial of UXOQCS
1. Determine seed parameters	Number of seeds: (A) Anticipated Production Rate for Team: _____ acres/day (B) Total Personnel on Team: _____ (C) Quantity of targets to be placed per acre: $B * 2/A =$ _____		
2. Labels	Are the seed labeled as required by this SOP?		
3. Documentation	Are the emplacement data recorded as required by this SOP?		
4. Data management and reporting	Is the seeding information in location kept unavailable to the production surface sweep personnel?		
5. MPC Documentation	Have the MPCs for from Worksheet 12 been achieved for the surface sweep seeds?		

UXOQCS: _____ Date: _____

EM61-MK2 Field Procedures for Munitions Response

1. Purpose

The purpose of this Standard Operating procedure (SOP) is to identify the means and methods for setting up and performing terrestrial, person-portable digital geophysical mapping (DGM) field surveys with the Geonics, Ltd. EM61-MK2 in support of munitions response activities.

EM61-MK2 data collection involves navigating the sensor along transects at a spacing intended to meet the project objectives for detection of geophysical anomalies indicative of potential munitions items in the subsurface.

This SOP is intended to complement the project-specific Uniform Federal Policy (UFP) Quality Assurance Project Plan (QAPP), Geophysical Investigation Plan (GIP), or other project-specific work planning documents. These documents provide the necessary details regarding the specific roles and qualifications of geophysical personnel, site history, conceptual site model, technical approach, quality control (QC) testing requirements, measurement quality objectives (MQOs), and other information relevant to the project.

2. Personnel

The following individuals are involved in performing field surveys with the EM61-MK2:

- Site Geophysicist
- Project Geophysicist
- QC Geophysicist
- Data Processing Geophysicist

The roles and responsibilities of project personnel may vary depending on the nature and scope of the investigation. Refer the project-specific work planning documents for this information.

3. Geophysical Sensor, Equipment, and Materials

The following is a list of required equipment and materials for operation of the EM61-MK2 in person-portable configuration:

- EM61-MK2 sensor including: coils, processing electronics, batteries, cables, wheels, tow handle and chargers (note: when conducting a survey using fiducial positioning method, an interface cable with a marker button is needed)
- Materials needed for configuration of sensor (e.g. manufacturer wheels for wheel mode, fiberglass poles for 2-person tandem mode).
- Real-time kinematic Global Positioning System (RTK GPS) or equivalent survey-grade positioning system, as needed
- EM61-MK2 tripod for mounting positioning system receiver atop center of coils, as needed
- Data collector (Allegro Field Computer, Archer, or equivalent) with *DAT61-MK2* and *Nav61-MK2* collection software
- Munitions Response Site Information Management System (MRSIMS) tablet computer for recording field notes
- Field book for keeping back-up copies of field notes

- Field survey grade tape measures
- Non-metallic materials for use in maintaining line spacing and marking fiducials (e.g. marking paint, bean bags, plastic pin flags, etc.) during line and fiducial surveys.

4. Procedures and Guidelines

4.1 Sensor Setup

Connect all parts and cables for the desired deployment mode. Surveys conducted with GPS or equivalent positioning system will generally require both EM61-MK2 coils to be assembled using the manufacturer's standoff poles for attaching the tripod. Surveys conducted using fiducial positioning methods may only require use of the bottom coil.

The signal cable connects bottom coil to "COIL" port on backpack using the military-style connectors. These ends are gender specific. The interface cable connects the processing electronics to the designated COM port for the EM on the data collector.

Set the two backpack knobs shall be set to "M" and "4", where the "4" indicates 4-channel mode operation (the "S" setting is used only when synchronizing multiple sensors and "D", or differential mode, is used when measurements from the top coil and only 3 time gates from the bottom coil are desired).

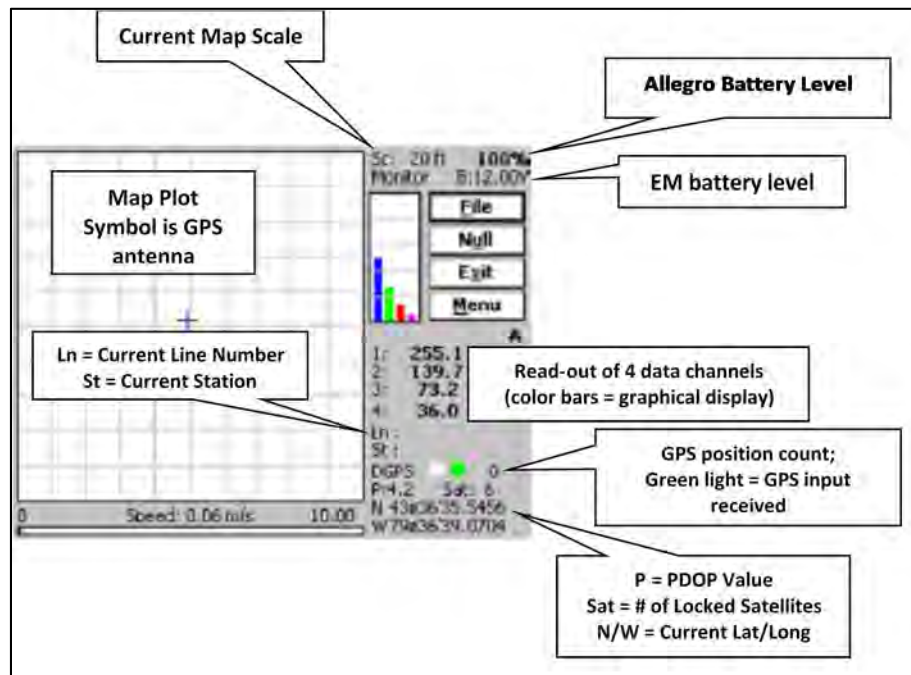
Turn on the instrument. Check on top of the backpack that the red light is ON and that there is an audible tone coming from the backpack (use volume control knob as needed).

Allow the sensor to warm up for at least 15 minutes (instrument remains stationary), preferably at least 15 feet away from large metallic objects at the surface. Longer warm-up times (~30 minutes) may be needed when working in cold temperatures.

Turn on data collector and launch *Nav61-MK2* (if conducting line and fiducial survey, *DAT61-MK2* is needed). Update your survey parameters through the main menu. **Verify the specific parameters with the QC Geophysicist prior to start of field operations.**

Once the survey parameters have been set, enter the logging menu to begin survey. A sample graphic from Nav61MK2 is presented as **Figure 1**.

Figure 1. Screen Capture of Nav61-MK2 Software



Additional set-up steps include the following:

- Record DGM and positioning instrument serial numbers in MRSIMS.
- Verify that EM battery voltage is >12.00 Volts and Allegro battery is >50%. If not, click “Exit” and from main menu, turn off Allegro and EM61-MK2. Replace battery.
- Verify that the EM61-MK2 operator is not wearing steel-toe boots and has no metallic objects in their pockets.
- Verify that there is a valid GPS input received; a flashing green light status indicated data are streaming into the GPS port. It is recommended to preview the incoming GPS message in the GPS port set up menu to make sure the proper message (e.g. GGA) is received (the wrong message may result in improper RTK quality designation).
- Position the sensor in a location that appears to be relatively free of response from metal. Click “Null”. System will go through its nulling sequence.
- Once complete, read-out should be near zero for all 4 channels.
- Data file storage shall be set to the data collector internal hard drive in order to avoid file corruption and data loss if the external card fails.

4.2 Positioning System Accuracy Check

Prior to start of data collection each day, a positioning system accuracy check will be performed. The rover unit will be placed on a survey pole, and the operator will occupy a pre-established “check” location (this is typically a monument or temporary benchmark installed by a professional land surveyor [PLS]). A measurement will be carefully taken, ensuring proper centering and leveling, and stored in the positioning system data collector. The offset between this stored measurement and the reported

ground truth provided by the PLS will be validated by the DGM field team for compliance with the project-specific MQO.

4.3 Sensor Function Test Measurements

Static background and static spike function tests will be performed, at a minimum, at the beginning and end of each production day to demonstrate that the sensor components are operating within industry-accepted standards for munitions detection. Additional function tests may be required in accordance with the work planning documents (e.g. between each data collection sortie [e.g. grid or transect block]). Refer to these documents for details on measurement duration, frequency, and established MQOs.

Each static spike measurement shall be bracketed by a static background measurement, for a total of 3 measurements per test. The spike shall consist of an industry-standard object (ISO) from the McMaster-Carr online catalogue. Do not purchase threaded pipe nipples from big box hardware stores such as Home Depot and Lowe's because specifications of the pipes nipples can vary and adversely impact test results.

Typically the small Schedule 40 ISO is used for this test because it is logistically easier to work with and place on a test jig. In addition, published responses (Naval Research Laboratory [NRL], 2009) exist for the ISOs, against which measured responses in the field can be evaluated.

The ISO shall be placed on a non-metallic test jig such that it is centered over the EM61-MK2 bottom coil (Figure 2).

Figure 2. Sample EM61-MK2 Spike Test Jig with Small Schedule 40 ISO



The distance between the ISO center of mass and EM61-MK2 bottom coil shall be precisely measured and recorded in MRSIMS along with the orientation of the ISO.

The McMaster-Carr information for the small, medium, and large ISOs is as follows:

Item	Nominal Pipe Size	Outside Diameter	Length	Part Number ¹	ASTM Specification
Small ISO	1"	1.315" (33 mm)	4" (102 mm)	4550K226	A53/A773
Medium ISO	2"	2.375" (60 mm)	8" (204 mm)	44615K529	A53/A773

Large ISO	4"	4.500" (115 mm)	12" (306 mm)	44615K137	A53/A773
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¹ From the McMaster-Carr catalog (<http://www.mcmaster.com/>).

4.4 Additional Sensor Quality Control Tests

Additional QC tests to be performed during DGM may vary between projects. The project-specific work planning documents contain the details on the required tests, requirements for testing frequency, and pass criteria. In addition to the sensor function tests, the following tests shall serve as the minimum requirements for an EM61-MK2 survey conducted in support of munitions response activities:

- Personnel test to evaluate the effect of the DGM operator on the sensor
- Cable shake (vibration) test to identify excessive noise due to movement of cables or connectors

4.5 IVS Surveys

Prior to commencement of production surveying, each EM61-MK2 sensor to be used shall undergo initial validation at an Instrument Verification Strip (IVS) in accordance with the Geophysical System Verification (GSV) process (Nelson and others, 2009). The project GIP and GSV Plan provide details on the IVS construction details and procedures. The general sequence of steps includes collection of a background (pre-seeded) survey with the EM61-MK2 to identify a suitable IVS location, construction of the IVS and emplacement of seed items, culminating in collection of the 5-line (post-seeded) IVS. The EM61-MK2 must be validated for dynamic response, dynamic positioning, dynamic repeatability, lane spacing, and walking speed using the IVS before production data can be accepted. The 5-line survey shall be conducted using the positioning method(s) to be utilized for the project.

After initial validation is completed, the EM61-MK2 sensors shall be used to collect the IVS seeded and background (i.e. noise line) transects at the start and end of each day data collection is performed. This 2-line survey shall be completed using the positioning method planned for the day's operations. The seeded transect shall be collected in two directions, once up the line and again back down the line. Each pass along the IVS transects shall be recorded as separate lines within the data file. This process is intended as an on-going validation of the sensor dynamic response and positioning.

4.6 Production Survey Collection

Production surveying involves collecting data along transects across the survey area. Data collection may be performed across grids or along transects. Established MQOs will vary depending on the intended survey coverage.

Data collection is controlled by the operator/user with the DAT61-MK2 or Nav61-MK2 software, which allows the user to assign a numerical ID to each transect line and start/stop data collection at the beginning/end of each transect. When an obstacle is encountered along a transect, the obstacle can be avoided by either altering the path of the transect or stopping data collection when the obstacle is encountered and resuming a new ID transect on the other side of the obstacle (**when using line and fiducial navigation, collection must stop at obstacles and resume on the other side of the obstacle; the path cannot be altered**).

Data acquisition will generally be performed in the following steps:

1. **Sensor Assembly.** Section 4.1 describes the sensor assembly procedures.

2. **Perform sensor function tests and QC tests.** Sections 4.2 through 4.5 present the sensor function tests and minimum QC test requirements
3. **Collect Survey Data.** When using GPS or other external positioning systems, navigation within grids is performed with the assistance of markers and the Nav61MK2 track path display. This can be accomplished by marking the track of the inside wheels as the sensor moves along a survey transect. Data collection along each transect will start and end at least one full EM61-MK2 sensor length beyond the edge of the grid. This process facilitates full coverage of the survey grids and minimizes the occurrence of data gaps at grid edges. When collecting data using fiducial positioning methods, the same process applies as with the use of GPS, although the operator will also need to insert fiducials (digital “tags”) in the data stream by depressing the marker button on the interface cable. No track path display is available in DAT61-MK2. The fiducial marks are inserted at known locations within the grid or along the transects. These markers are typically wooden surveyor stakes (for transects) or ropes or tape measures laid out at known along-line distances within each grid. The button is depressed as the center of the EM61-MK2 coils pass over the marker. Knowing the precise location of these markers is essential for proper data positioning during data processing; therefore, detailed notes shall be recorded in MRSIMS noting their positions. For transect fiducial surveys, the stake positions are typically recorded by a land surveyor to survey-grade accuracies.
4. **Validate field data.** While validation of the data is finalized after DGM QC, the field teams shall perform initial data validation in the field in order to maximize efficiency of the data processing and minimize or avoid time spent collecting bad data. The integrity and quality of the data may be validated by careful attention to QC test results, on-screen displays on the data collectors, and keeping timely and accurate field notes. Field validation shall be performed to do the following:
 - If a QC test failure is observed and can be attributed to a system component, the field team can implement an immediate corrective action (e.g. replace a bad battery, malfunctioning component, etc.).
 - The track path display (in Nav61MK2) can be monitored to observe potential GPS drop outs or gaps in line spacing, and if necessary, an immediate correction action can be implemented (e.g. use a different navigation aid)
 - For fiducial surveys collected with the instrument in wheel mode, the displayed line lengths in the data collection software from the EM61-MK2 odometer can be compared against the lengths read directly from the tape measures or other navigation aids used in the field, and if necessary, an immediate correction action can be implemented (e.g. re-collect suspect line or line segment)

5. Data Management

Field notes will be recorded in the MRSIMS tablet computer. The MRSIMS forms are intended to capture the critical information needed for processing and QC of the DGM data. This information includes, but is not limited to, site-specific conditions, weather conditions, field personnel names, DGM team IDs, sensor assembly measurements and details, IVS, QC, and production file names, documentation of required IVS and QC tests having been performed, data sortie IDs and details, fiducial start and end locations, and daily lessons learned. Information should be entered into the tablet in real-time for submittal at the end of each work day. In the event the tablet battery dies or is otherwise unable to be used, detailed hand-written notes shall be recorded in a field log book and entered into the tablet forms as soon as possible.

Data will be transferred at the end of collection each day from the data collector to a laptop computer. Data may be first transferred to an external storage card or flash drive at this time to facilitate quicker copying from the DGM or GPS data collector to the lap top.

Prior to submittal for data processing, the DGM field team leader shall be responsible for verifying the completeness of the daily raw data and field notes submittal (or delegate this task to another field team member). Data must be field verified before being submitted for processing. The following elements shall be verified:

- Consistent raw data file nomenclature for IVS, QC and production files
- QC test files containing at least the date and team ID
- Completeness of raw instrument files, removing bad or incomplete data files or re-downloading missing files
- GPS data file format (Microsoft Excel or text file format)
- Legible copies of log book entries, including dates (pdf or image files of hand written notes)
- Completeness of MRSIMS entries (DGM Daily and DGM Survey forms) and reconciliation with instrument file names

Once all data have been field verified, files will be uploaded to the project-specific file transfer protocol (FTP) or Share Point site. An email will be sent to the Data Processing Geophysicist and QC Geophysicist notifying them of file upload.

6. Quality Control

As part of CH2M HILL's QC program, QC failures or inability to meet a specific MQO will trigger a root cause analysis (RCA). This process must be undertaken so as not to presuppose the corrective action (CA) without fully understanding the root cause of the failure and implications for data usability. Exceptions include identification in the field of a malfunctioning sensor component by the field team, where an immediate CA can be implemented and monitored.

If a QC test fails or an MQO is not met, the QC Geophysicist shall first document the non-conformance event. In conjunction with the relevant project personnel, an RCA will be conducted in order that informed decisions can be made regarding the usability of the affected data. The RCA process includes identification and documentation of the root cause, contributing factors that led to the failure, and measures that will be taken for immediate corrective action as well as to prevent future occurrences. The non-conformance, RCA, and CA will be documented in the report format required by the project-specific planning documents. This documentation shall undergo Senior Geophysicist review.

Each member of the DGM team is responsible for QC and has the authority to halt data collection if a quality issue presents itself. Potential data quality issues will be communicated immediately to the QC Geophysicist in order to begin the RCA process as quickly as possible and minimize data collection downtime or adverse impacts to project schedules.

7. References

Naval Research Laboratory, 2009. *EM61-MK2 Response of Three Surrogates*, NRL/MR/6110-09-9183. March.

Nelson, Herb, Katherine Kaye, Ann Andrews, 2009. *Final Report Geophysical System Verification (GSV): A Physics-Based Alternative to Geophysical Prove-Outs for Munitions Response*. July.

Process Standard Sensor Data for Munitions Response

1 Purpose

The purpose of this Standard Operating Procedure (SOP) is to describe the procedures for processing digital geophysical mapping (DGM) data in support of Munitions Response (MR) activities. It also presents the procedures for delivering data packages containing quality control (QC) and production data and results.

This SOP is applicable for processing data collected with the Geonics, Ltd. EM61-MK2 or Geometrics G-858, used in conjunction with either global positioning system (GPS) or fiducially positioned data. Field notes are recorded using CH2M HILL's Munitions Response Site Information Management System (MRSIMS). MRSIMS is also used to track data processing progress and completion status of data packages throughout the project. Processing of DGM data is performed in the Geosoft Oasis Montaj (Geosoft) environment.

Refer to the project-specific Uniform Federal Policy (UFP) Quality Assurance Project Plan (QAPP), Geophysical Investigation Plan (GIP), or other master work planning documents for details regarding the specific roles and responsibilities of geophysical personnel, site history, conceptual site model, technical approach, objectives, QC requirements, measurement quality objectives (MQOs), and other information relevant to the project.

2 Personnel

The following individuals will be involved in the processing of DGM data:

- Project Geophysicist
- QC Geophysicist
- Data Processing Geophysicist

The roles and responsibilities of project personnel may vary depending on the nature and scope of the investigation. Refer the project-specific work planning documents for this information.

3 Procedures and Guidelines

This section describes the procedures used to process the DGM data including positioning and leveling of the data, processing/assessing the QC activities related to the DGM data collection, and the selection of anomalies from the final processed data.

3.1 Processing of DGM data

The processing of dynamic DGM data is achieved in the following steps:

1. Raw data conversion and import into Geosoft
2. QC test data processing
3. Production DGM data processing
4. Target selection

Process Standard Sensor Data for Munitions Response

3.1.1 Data Conversion and Import

The raw instrument data files are converted to Geosoft compatible *.XYZ files using the instrument-specific data conversion program, and subsequently imported into a Geosoft Database (*.GDB). For G-858 data, diurnal corrections using the base station data (if usage required in the project work planning documents) is performed at the time of export. The imported data are inspected and assessed against the MQOs provided in the project-specific work planning documents depending on data type (QC or production DGM data).

3.1.2 QC Test Data Processing

The processing of the QC test and Instrument Verification Strip (IVS) data is intended to validate initial and ongoing data against the established MQOs. Initial QC and IVS data are also used at the start of the project to validate the survey design as well as derive information that is integral to subsequent processing steps and target selection. The project-specific work planning documents provide the details on the data validation and QC testing methods, frequency, and MQOs.

QC and IVS data shall be processed to derive or validate the following:

- Static spike response (sensor functionality)
- Static background response
- Dynamic sensor noise levels
- Dynamic system positioning accuracy
- Dynamic system response repeatability
- Intended survey lane spacing
- Latency/lag correction
- Intended sample separation and walking speed

Processed QC test data shall include the following outputs:

- Background corrected sensor response value (mean static spike minus mean static background)
- Analysis of personnel and vibration test
- Analysis of background response and static sensor noise levels
- Geosoft Static Calibration Plots (*.MAP and *.PDF format)
- Geosoft Static Calibration Database in Geosoft Database (*.GDB) and ASCII (*.XYZ) formats
- Raw, merged, processed instrument files

Processed IVS data shall include the following outputs:

- Calculated latency/lag correction
- Analysis of dynamic background response and sensor noise levels
- Validation of proposed lane spacing
- Seed item offsets
- Seed item dynamic response amplitudes
- Geosoft IVS Map Plots (*.MAP (Packed) and *.PDF format)

Process Standard Sensor Data for Munitions Response

- IVS target list in Geosoft Database (*.GDB) format and Microsoft Excel format
- Processed IVS data in Geosoft Database (*.GDB) and ASCII (*.XYZ) formats
- Raw, merged, processed instrument files

A QC tracking sheet will be used to monitor sensor function and IVS results requiring ongoing validation. IVS seed item response results will be tabulated and measured against applicable Naval Research Laboratory (NRL) instrument response curve data (NRL, 2009). Static spike measurements will also be tabulated and measured against the applicable response curve data in NRL (2009).

QC test data (including IVS data) will be delivered by date in accordance with Section 4 of this SOP. The raw data directory shall contain the original unaltered instrument files. The merged data directory shall contain the positioned data files (if created) and raw .xyz files. The processed data directory shall contain the final Geosoft data files. Finally, the Images directory shall contain the PDF format files associated with the various QC tests.

3.1.3 Production DGM Data Processing

The processing of the production DGM data requires analysis of the data to ensure that project-specific MQOs are being achieved in each dataset. Data measurements that do not pass the MQOs are identified by a series of automated processing routines that are used to flag data where the MQOs are not met. This maintains the chronologic integrity of the DGM data and prevents the out-of-specification data from being used for targeting.

DGM data shall be reviewed upon import to validate the data against the following MQOs:

- Along-line measurement spacing (sample-separation)
- Cross-line spacing (survey coverage)
- Navigational data quality (RTK fix, positioning of fiducials, etc.)

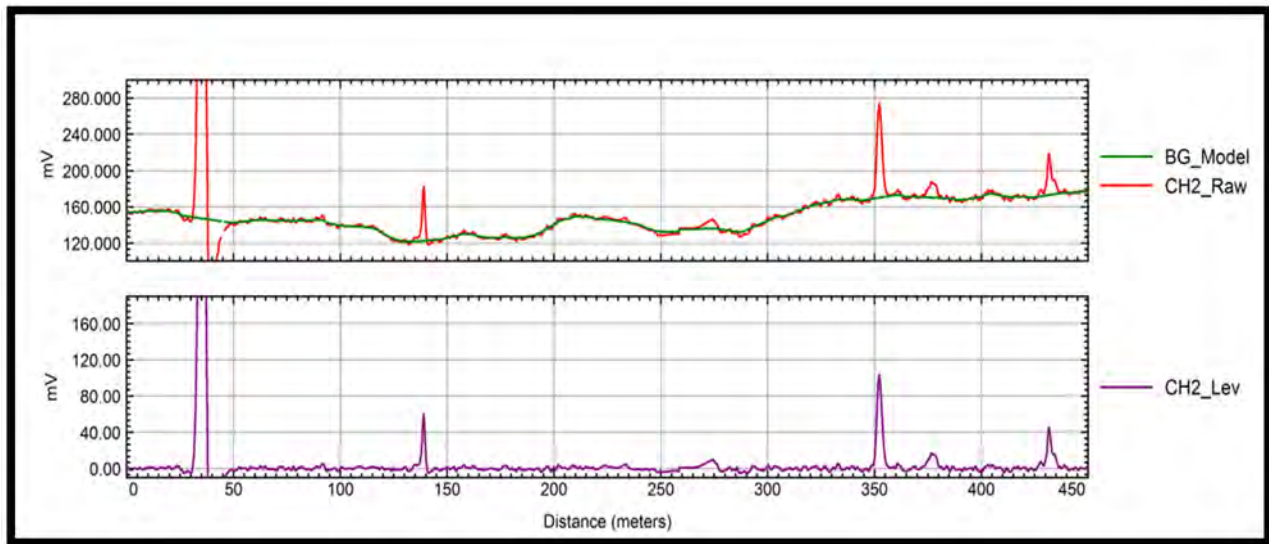
Project-specific metrics will be calculated and documented in MRSIMS per data sortie. If data do not meet an MQO or a data quality issue is suspected, the QC Geophysicist and field team will be notified and a root cause analysis (RCA) shall begin (see Section 5).

Further processing of DGM data will, at a minimum, include the following elements:

- Re-projection of data positions to project-specific coordinate system and datum
- Application of necessary latency or lag correction
- Determination of the background model and leveling of sensor data, as needed (see **Figure 1**). For EM61-MK2 this includes Channels 1-4; for G-858 data, this includes the Vertical Gradient response. Leveling may be performed using a variety of routines and incorporate filters as needed.

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Figure 1. Example of Raw vs. Levelled Data



The leveled DGM data are subsequently gridded using a Geosoft gridding algorithm (e.g. Minimum Curvature). Gridding parameters will vary by project lane spacing and data density. For EM61-MK2 data, all 4 channels will be gridded for use during target analysis. The gridded sensor response data are then used for amplitude response-based target selection whereby the position of peak responses in the data that exceed the project threshold are selected and identified as target anomalies for further analysis.

3.1.4 Target Selection

Before target selection begins, a minimum threshold is established after analysis of sensor noise levels in dynamic response data (IVS and available production data) and determination of the background response model. This analysis is important for selecting a target threshold that does not result in targets being selected from within the sensor noise range. The Data Processing Geophysicist shall monitor the sensor noise levels and background response models in order to evaluate whether noteworthy variations occur across the site with respect to the background response model or sensor noise levels.

For gridded data sets, target selection is performed using an automatic grid peak detection algorithm in Geosoft (e.g. Blakely Test) using the established target selection threshold on the designated sensor channel(s). After the data have been gridded, the Geosoft automatic grid peak detection algorithm is used to extract locations of all grid peaks that are above the project detection threshold. For transect surveys, target selection may be performed using the Pick Peaks Along Profile algorithm. The target selection method, procedure, and justification are entered by the Data Processing Geophysicist in the MRSIMS processing notes.

Anomalies will be assigned a unique target ID in MRSIMS upon import, which incorporates a grid or survey area identifier. To maintain the integrity and continuity of the initial picked target list, target IDs will also incorporate the original Geosoft target ID as assigned by the grid peak detection algorithm.

Anomalies selected from EM61-MK2 data will be further analyzed using all four channels of data. Anomaly locations will be resampled within the target database from the CH1 through CH4 gridded

Process Standard Sensor Data for Munitions Response

data. Any anomalies exhibiting an abnormal decay will be masked or categorized separately from valid anomalies. Anomalies selected from G-858 data will be further analyzed using the vertical gradient response and analytic signal, as appropriate. Anomalies exhibiting abnormal characteristics will be masked or categorized separately from valid anomalies.

Manual review of all anomalies will be performed by the Data Processing Geophysicist, and any anomalies found to be invalid or incorrectly located will be adjusted or removed. Depending on project needs, anomalies may be categorized based on calculated characteristics (e.g. response, size, signal-to-noise ratio, source, etc.). The final list will be reviewed by the QC Geophysicist prior to finalization and delivery.

3.1.5 Processed DGM Data outputs

Processed DGM data shall include the following outputs:

- Processed DGM data in Geosoft Database (*.GDB) and ASCII (*.XYZ) formats
- Final target list per grid in Geosoft Database (*.GDB) format and ASCII (*.XYZ) or Microsoft Excel formats
- Geosoft Map Plot (Packed) per grid or survey area (*.MAP and *.PDF format)
- MRSIMS delivery report

Processed DGM data will be delivered by data sortie and in accordance with Section 4 of this SOP. The raw data directory shall contain the original raw, unaltered instrument files. The merged data directory shall contain the positioned data files (if created) and raw .xyz files. The processed data directory shall contain the final Geosoft data files. Finally, the Images directory shall contain the PDF format files associated with the production survey data.

4 Data Management

Processed DGM data will be delivered for QC to a secure directory on the project-specific file transfer protocol (FTP) site. The FTP site shall be used to transfer information to the CH2M HILL project team members during the project and is not intended for long-term or permanent storage of data.

After data have undergone QC and are finalized, the data packages will be moved to a secure CH2M HILL network server for storage.

Upon completion of the data processing and entry of the DGM processing forms in MRSIMS, production data are assembled into final delivery packages that includes the following:

- Raw instrument files per grid or survey area
- Positioned (i.e. merged) instrument files
- Processed DGM data per grid or survey area in Geosoft Database (*.GDB) and ASCII (*.XYZ) formats
- Final target list per grid or survey area in Geosoft Database (*.GDB) format and ASCII (*.XYZ) formats
- Geosoft Map Plot (Packed) per grid or survey area (*.MAP and *.PDF format)
- MRSIMS Final Data Delivery Report

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The MRSIMS report will contain a copy of the field notes logged in MRSIMS as well as the processing details for the delivered data set. In addition, the MRSIMS report will contain the list of QC files that are associated with the data package. QC test data will be delivered in packages organized by date, containing the elements listed in Section 3.1.2.

5 Quality Control

As part of CH2M HILL's QC program, QC failures or inability to meet a specific MQO will trigger a root cause analysis (RCA). This process must be undertaken so as not to presuppose the corrective action (CA) without fully understanding the root cause of the failure and implications for data usability. Exceptions include identification in the field of a malfunctioning sensor component by the field team, where an immediate CA can be implemented and monitored.

If a QC test fails or an MQO is not met, the QC Geophysicist shall first document the non-conformance event. In conjunction with the relevant project personnel, an RCA will be conducted in order that informed decisions can be made regarding the usability of the affected data. The RCA process includes identification and documentation of the root cause, contributing factors that led to the failure, and measures that will be taken for immediate corrective action as well as to prevent future occurrences. The non-conformance, RCA, and CA will be documented in the report format required by the project-specific work planning documents. This documentation shall undergo Senior Geophysicist review.

Each member of the DGM team is responsible for QC and has the authority to halt data collection if a quality issue presents itself. Potential data quality issues will be communicated immediately to the QC Geophysicist in order to begin the RCA process as quickly as possible and minimize data collection downtime or adverse impacts to project schedules.

6 References

Naval Research Laboratory, 2009. *EM61-MK2 Response of Three Surrogates*, NRL/MR/6110-09-9183. March.

Quality Control of Standard Sensor DGM Data

1 Purpose

The purpose of this Standard Operating Procedure (SOP) is to identify the processes undertaken to perform Quality Control (QC) of Digital Geophysical Mapping (DGM) data collected using the Geonics, Ltd. EM61-MK2 instrument, the Geonics, Ltd. EM31 terrain conductivity meter, and the Geometrics G-858 magnetometer.

This SOP is intended to complement the project-specific Uniform Federal Policy (UFP) Quality Assurance Project Plan (QAPP), Geophysical Investigation Plan (GIP), or other project-specific work planning documents. These documents provide the necessary details regarding the specific roles and qualifications of geophysical personnel, site history, conceptual site model, technical approach, quality control (QC) testing requirements, measurement quality objectives (MQOs), and other information relevant to the project.

2 Personnel, Equipment and Materials

The following individuals will be involved in the QC of DGM data:

- Senior Geophysicist
- Project Geophysicist
- QC Geophysicist
- Data Processing Geophysicist

The roles and responsibilities of project personnel may vary depending on the nature and scope of the investigation. Refer the project-specific work planning documents for this information.

3 Procedures and Guidelines

3.1 Team Chartering

Success of the project relies on each project team member's understanding of their role, the DGM objectives, QC requirements, and the Measurement Quality Objectives (MQOs). The CH2M HILL Project Manager is responsible for chartering the whole project team, but the QC Geophysicist and Senior Geophysicist are responsible for chartering the DGM team on the relevant technical details. It is the responsibility of each team member to ask questions when a project requirement or procedure is not clear.

3.2 Project Setup

3.2.1 File Transfer Sites

The QC Geophysicist or designee is responsible for setup of a secure File Transfer Protocol (FTP) site if one does not already exist for a project. The FTP is an effective way to transfer data between project team members but is not intended for long-term or permanent storage of data files. The project Share Point site may be used in lieu of the FTP site for transfer of data during the course of the project. The QC Geophysicist shall confirm with the Project Manager that all team members have access and full upload and download rights to the Share Point site.

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3.2.2 GIS

The QC Geophysicist or designee shall gather the necessary project-specific Geographical Information System (GIS) data from the Project Manager or GIS personnel. The QC Geophysicist shall verify completeness of the information, and validate the following:

- Files are in the projection specified in the planning documents, confirming proper datum and units
- Display the site-wide grid system (if applicable) and confirm grid dimensions
- Confirm the size of the DGM survey area compared to what is presented in the site description section of the planning documents

3.2.3 Land Survey Data Review

If a professional land surveying (PLS) subcontractor is utilized for the project, the QC Geophysicist or designee is responsible for obtaining the data submittals from the Project Manager and verifying submitted information is complete and complies with the PLS scope of work.

QC of the surveyor data should be performed to validate the following:

- Details of the temporary benchmarks are provided in the surveyor's report with regards to accuracy, projection, and units
- Recorded measurements of emplaced stakes at grid corners, transect locations, or other points that were acquired in the field from CH2M HILL-supplied coordinates; offsets between the planned coordinates and as-staked measurements shall be calculated in order to validate that the markers meet the accuracy requirements
- Recorded measurements of QC seeds or IVS seeds were performed after the items were precisely placed in the ground

3.2.4 Munition Response Site Information Management System (MRSIMS)

The QC Geophysicist or designee shall complete the *MRSIMS Tablet Project Setup Form* and return to the MRSIMS database coordinator. Prior to mobilization of DGM staff to the project site, the QC Geophysicist shall make sure MRSIMS is set up for the project and arrangements have been made for the tablet computers to be onsite in time for data collection.

3.3 Field Kick-off

The QC Geophysicist should be onsite to kick-off the DGM survey. If that cannot be done, the QC Geophysicist shall confirm the Field Team Leader has the proper planning documents and SOPs onsite and is prepared to perform the following:

- Confirm at least two temporary benchmarks have been established in an appropriate location (if using Real Time Kinematic-Global Positioning System (RTK-GPS)).
- Confirm grid/transect stakes have been properly marked. Grid IDs should be labeled on the southwest corner stake.

Quality Control of Standard Sensor DGM Data

- Confirm that additional staked features (e.g. survey area boundary, proposed soil sampling locations, etc.) are clearly differentiated from grid or transect stakes in order to avoid navigation errors by the DGM field team.
- Confirm that QC seeding has been completed and that no physical markers remain at the seed locations.
- Assist with selection of a suitable IVS location and construction of the IVS; verify that proper IVS documentation has been performed (e.g. seed items photographed, depths recorded, survey-grade measurements of seed items and transect start/stop points are taken)

3.4 QC of Field Information

Field teams are required to perform initial validation of field data and verification of data files and field notes prior to submittal at the end of the day. The Data Processing Geophysicist is responsible for QC of the MRSIMS field forms and shall endeavor to identify incomplete records or catch errors prior to submitting processed data for QC. The QC Geophysicist is ultimately responsible for final verification of the field information prior to delivery of the data package to the client.

Field information that must be reviewed as part of the QC process includes, but is not limited to, the following:

- File names for QC tests and production data
- Proper number and frequency of QC test files per data set
- Completeness of MRSIMS entries
- Completeness of supporting GPS data files

3.5 Daily QC Test and IVS Tracking

Daily static sensor tests and dynamic QC test results required in the project-specific planning documents shall be tracked in a Microsoft Excel spreadsheet for easy reference. All physical measurements that affect the response (e.g. height of instrument, distance of spike from sensor, etc.) shall also be reported in the tracking sheets. Daily GPS accuracy checks can also be tracked in these spreadsheets by adding a worksheet that computes the offset of the recorded GPS check measurement to ground truth provided by the PLS.

The QC Geophysicist shall perform QC of the static measurements and IVS data by evaluating the repeatability of sensor noise levels (see Section 3.6.2) and comparing them to the initial noise levels derived at the start of the project. In addition, QC of these data shall include review of the amplitude responses compared to predicted responses (Naval Research Laboratory [NRL], 2009) and a review of the positioning accuracy of the detected seed items in the IVS. QC of these test data is important to identify potential sensor problems as well as mistakes in leveling, improper lag corrections or targeting during processing of dynamic response test data, or errors in populating the tracking sheet.

The tracking sheet shall be populated by the Data Processing Geophysicist and updated with each processed data set. Results shall be tabulated and graphed. The tracking sheets may be modified to accommodate reporting of QC results for DGM surveys conducted with the G-858 and EM31. Recall that

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different sensors may require different QC test criteria and frequency. The project-specific work planning documents contain the details of the QC test requirements, pass criteria, and MQOs.

3.6 DGM Survey Data QC

QC of the DGM survey data intends to finalize validate the data against the established QC requirements and MQOs for a project, thereby assessing the usability of the data. QC is also intended to verify that the elements of the data package are complete and correct prior to delivery of the client. Final verification includes review of the final DGM maps contain for the proper map elements (see Section 3.7).

3.6.1 Survey Line Start/End Locations and Distances for Fiducial Surveys

For fiducial surveys, the reported start/end locations and distances in MRSIMS shall undergo QC for at least a subset of survey lines. This step is performed by comparing the derived positions and lengths in the Geosoft database (.GDB) file to the field notes. Typically the MRSIMS field notes are exported during data processing as a Microsoft Excel file.

The QC process shall initially focus on lines where field team comments may indicate a potential problem in navigation or discrepancy between the measured taped distance and the reported distance by the encoder. This QC step is intended to identify improperly positioned lines that may have been overlooked during positioning and subsequent processing of the fiducial data. If discrepancies >1 meter (m) (3.3 feet [ft]) between reported distances in the field notes versus what is presented in the Geosoft .GDB file, the remainder of the lines in the data set shall be reviewed.

3.6.2 Sensor Noise Level and Data Leveling QC

QC of the leveled sensor response data is intended to evaluate the sensor noise levels, which for most standard sensor DGM surveys will serve as the primary basis for target selection. Sensor noise levels shall be evaluated in the static test measurements, dynamic IVS surveys, and in the production data in order to monitor the data for unusual fluctuations in the background model or sensor noise levels. Such occurrences may be attributable to atmospheric conditions or site-specific conditions, particularly for large sites, developed sites with various external noise sources, sites with variable terrain, or variable geologic conditions for those sensors whose response can be significantly influenced by geology. However, unusual fluctuations may also be diagnostic of instrument problems or indicative of a deviation from established field procedures.

Sensor noise levels are evaluated in the Geosoft database (.GDB) by computing the standard deviation of the desired channel response from a portion of the data set that appears to be readily free of anomalous responses. Tracking the static background measurements in the spreadsheets (Section 3.5) is a useful means by which to quickly identify fluctuations. For the production survey data, checks of the sensor noise levels from multiple lines within a Geosoft database (.GDB) shall be performed.

Data leveling is performed to a degree appropriate for the sensor and the site-specific background model. A review of the leveling routines is performed by using the Channel Math function to subtract

Quality Control of Standard Sensor DGM Data

the raw instrument response from the filtered or leveled data channel (not the latency or lag corrected channel). By plotting the raw and leveled responses on top of each other in Geosoft along with the resulting difference channel, comparisons can be made from one line to the next in the database regarding the degree of leveling applied to the entire data set. If a significant change in the background model or degree of leveling occurs within a dataset, or from one dataset to the next, the QC Geophysicist shall make sure the reasons for these occurrences are adequately justified by the Data Processing Geophysicist.

This process also facilitates identification of portions of the survey area where custom scripts or automatic leveling routines in Geosoft may need to be augmented by manual leveling. An example of this condition could be a significant change between raw and leveled data for portions of survey lines on either side of a large-amplitude anomaly with a relatively large footprint, particularly if the leveled response trends negative beyond the outer edge of the anomaly footprint.

3.6.3 Survey Coverage QC

Survey coverage (cross line spacing) must undergo QC to evaluate it against the established MQO. This coverage is typically assessed by generating a .PLY file from the data set .GRD file and using the UX-DataPreparation | QC QA Tools | Foot Print Coverage menu selection in Geosoft. The sensor footprint is a required input, so it is critical to enter that value in the proper units. Cross-line data gaps will be evident as white spaces on the resulting map generated as part of this QC step.

3.6.3.1 Sample Separation QC

Down line data density must undergo QC to evaluate it against the established MQO. This evaluation also provides a check of the data collection speed.

The sample separation is checked using UX-DataPreparation | QC QA Tools | Sample Separation. The separation criteria must be specified in this test, so it is critical to enter that value in the proper units. If multiple sample separation MQOs exist, the test must be repeated using the different criteria. The resulting map from this Geosoft module flags locations that exceed the specified criterion and it computes the percentage of the total data set that has failed.

3.6.3.2 Target Selection QC

QC of discrete target selections is intended to perform the following (for those surveys where discrete target selection is part of the survey objective):

- Identify potentially invalid targets (e.g. those with poor decay [for EM61-MK2 surveys], those comprised of a single fiducial in the production survey database [noise spike], those with peak responses selected from within the sensor noise range, or targets that may be associated with grid or re-sampling effects)
- For gridded data sets, verify targets were not added based on peak amplitude response in profile view but rather targets were selected from the gridded data
- Evaluate targets associated anomalies along the boundary of the survey area or adjacent to an obstruction where the data do not definitively demonstrate that the peak was encountered

Quality Control of Standard Sensor DGM Data

- Identify inconsistencies in target selections in potential multiple target scenarios (e.g. picked peaks or picked location within established search radius for dig operation)
- Identify whether the data support selection of discrete targets with peak amplitudes below the established threshold
- Review saturated response areas (SRAs) and obstruction polygons to verify that 4 vertices define the target and that they do not violate MRSIMS rules
- Verify 100% of QC seeds were detected and selected as targets of interest

QC of discrete target selections is performed by comparing the delivered target .GDB files to the production survey results in both map and profile view for a thorough assessment. Subsequent review of the Microsoft Excel target lists is performed to validate the information contained in the Excel sheets is correct with regards to reported coordinates, sensor response, and target type.

3.7 QC of DGM Deliverables

The QC Geophysicist is responsible for reviewing the final data package for delivery to the client. Packages shall contain raw instrument data files, merged data files, packed .MAP files, [processed databases in Geosoft (.GDB) and Geosoft-compatible (.XYZ) format, PDFs of the static calibration plots and production area maps, and target lists.

Maps shall be evaluated for consistency and completeness. Minimum map elements that should be presented on each deliverable include the following:

- Scale bar
- Map projection with units
- Axes with coordinate labels
- North arrow
- Geophysical data color bar with title and units
- Map Legend
- Contoured data set with target selections and IDs
- Annotation of site features relevant to the interpretation of the data
- Data set identifier (i.e. grid ID, transect block ID, site ID)
- Title block containing map title, site location, map creator initials, map approver initials

4 Data Management QC

4.1 Deliverables

Data management QC is intended to facilitate compliance with the delivery of schedule, data archiving, and reporting requirements.

Quality Control of Standard Sensor DGM Data

4.1.1 Schedule

The schedule of delivery of DGM data is presented in the project-specific work planning documents. The QC Geophysicist is responsible for reviewing actual data package delivery dates for compliance with established delivery MQOs. If it is known that a delivery schedule cannot be met, the QC Geophysicist shall, as a first step, inform the Senior Geophysicist and Project Manager. Section 5 addresses the response to an inability to meet an established MQO.

4.1.2 Data Archive

During the course of the project, data files and information are transmitted via FTP or Share Point sites, as described in Section 2.2.

After data packages are finalized, they are to be archived appropriately on a secure CH2M HILL network server or other location provided by the Project Manager. The QC Geophysicist or designee are responsible for uploading the data packages and verifying that files are up to date.

Data shall not be archived on lap top hard drives, portable hard drives, other external storage media, or FTP sites. Information shall be compressed into zip files and placed on the network.

4.1.3 Reporting

The QC Geophysicist is responsible for providing DGM QC-related reports, IVS reports, or other interim reports required in the project-specific work planning documents. Reports shall be complete and will address the relevant QC metrics and MQOs. The QC Geophysicist shall coordinate with the Senior Geophysicist and Project Manager on review prior to client delivery.

5 Response to QC or MQO Failures

As part of CH2M HILL's QC program, QC failures or inability to meet a specific MQO will trigger a root cause analysis (RCA). This process must be undertaken so as not to presuppose the corrective action (CA) without fully understanding the root cause of the failure and implications for data usability. Exceptions include identification in the field of a malfunctioning sensor component by the field team, where an immediate CA can be implemented and monitored.

If a QC test fails or an MQO is not met, the QC Geophysicist shall first document the non-conformance event. In conjunction with the relevant project personnel, an RCA will be conducted in order that informed decisions can be made regarding the usability of the affected data. The RCA process includes identification and documentation of the root cause, contributing factors that led to the failure, and measures that will be taken for immediate corrective action as well as to prevent future occurrences. The non-conformance, RCA, and CA will be documented in the report format required by the project-specific planning documents. This documentation shall undergo Senior Geophysicist review.

Each member of the DGM team is responsible for QC and has the authority to halt data collection if a quality issue presents itself. Potential data quality issues will be communicated immediately to the QC Geophysicist in order to begin the RCA process as quickly as possible and minimize data collection downtime or adverse impacts to project schedules.

Quality Control of Standard Sensor DGM Data

6 References

Naval Research Laboratory, 2009. *EM61-MK2 Response of Three Surrogates*, NRL/MR/6110-09-9183.
March.

Attachment C
Blind Seed Firewall Plan

Blind Seed Firewall Plan

Introduction

This Blind Seed Firewall Plan has been developed to describe procedures for ‘firewalling’ the locations of ‘blind’ quality control (QC) seeds placed for the task being performed at the former Vieques Naval Training Range (VNTR). The intent is to describe the approach to keeping a firewall between CH2M personnel needing to know the types, depths, and locations of the QC seeds placed for QC evaluation purposes and those who cannot know this information as it would compromise the integrity of their data processing and classification.

Quality Control Personnel

CH2M team personnel involved in data collection, processing/classification, and intrusive investigation activities on the project will be firewalled from having access to information on the types, depths, and locations of seeds buried at each QC seed location until they have performed their data analysis, classification, and/or intrusive investigation tasks. The information will be provided to them only as needed for post-classification analyses, such as a root-cause analysis (RCA). The following personnel from the CH2M team are the only members of the team who will have access to the information:

- Survey personnel from subcontracted Professional Land Survey company (PLS)
- CH2M Unexploded Ordnance Safety Officer/Quality Control Specialist (UXOSO/QCS)
- CH2M Project Manager (PM) (to assist with mapping in Geosoft Oasis Montaj as needed)
- CH2M Quality Control Manager
- CH2M team geographic information system (GIS) technician (name TBD) (for preparing maps for reporting purposes)

Information Transfer/Storage

The QC seed data and associated information will be recorded by the subcontracted PLS staff and the CH2M UXOSO/QCS staff upon placement of the seeds in the field. Data files will be transferred only between the individuals identified in the Personnel section of this document. The information and data will be stored only on local drives and in a protected folder on the project website accessible only to the staff identified herein.

Commitment to Integrity of the Firewall

All staff identified in this document, or others added with the CH2M PM’s permission, will be required to provide a written (either email or hard copy) commitment to comply with the requirements established in this document. This commitment will be kept on record by the CH2M PM and added to the project files.

Attachment D
Draft Validation Plan

Draft Validation Plan

This Advanced Classification Validation Plan has been developed to describe procedures for validating the classification results of task being performed at the former Vieques Naval Training Range (VNTR). The intent is to provide assurance that there are no native targets of interest (TOI) classified as non-TOI. The validation process will be performed by selection of a number of 'verification/validation digs' designed to test the assumptions inherent in the classification approach.

This plan is intended to describe the validation rationale and a description of the initial approach. The final number and distribution of verification/validation digs required will be dependent upon a number of factors including but not limited to the details of the classification approach, performance against the QC and QA seeds, and the quality of the partial 'receiver operating characteristic (ROC) curves' derived from the intrusive investigations. It is anticipated that this plan will be amended prior to implementation based upon the above factors.

Background

The Advanced Geophysical Classification (AGC) task has two main components: an initial detection survey, followed by a cued investigation classification survey. The initial detection survey is essentially the first step in classification where potential anomalies are rejected based upon the detection threshold. Once an anomaly is identified, using advanced classification there are three ways for a target to be classified as a TOI:

- 1) Match any of the candidate TOI items in the library
 - a) As a munitions item identified in the Conceptual Site Model CSM
 - b) As a member of a cluster or group of similar polarizabilities (β s) that are identified as TOI through a set of analyst calibration digs
- 2) Have features that are typical of TOI (axial symmetry, thick walled, large)

Because the goal of the verification process is to demonstrate that no TOI were classified as non-TOI, it is instructive to restate the above in terms of how anomalies are classified as non-TOI. From this perspective anomalies are classified as non-TOI by:

- 1) The anomaly selection process (anomalies below threshold are by default, non-TOI)
- 2) Not matching any of the candidate TOI in the library
- 3) Not having β s that indicate the item is large, axially symmetric, and thick walled

The following discussion presents an initial approach to classification verification for each mode of classification (including initial selection), with emphasis on describing what thresholds will be tested and the rationale for these tests. Any verification failures will require a root cause analysis (RCA) and appropriate corrective action (CA) developed and implemented in consultation with the U.S. Army Corps of Engineers (USACE).

Anomaly Selection Verification

Anomaly selection can be performed using a traditional 'response amplitude' metric as well as an advanced detection approach. The former is analogous to conventional EM61 detection surveys that use the amplitude response of a monostatic, vertically coupled transmit (Tx) / receive (Rx) coil configuration. The difference between the EM61 and the TEMTADS being used in this mode is primarily the higher resolution of the TEMTADS sensor due to the smaller Tx/Rx coil footprints and more densely sampled data set. Detection performance is a function of the signal to noise ratio (SNR) of the detection method. In contrast the Advanced Detection approach makes use of the entirety of the much richer TEMTADS data set including all of the cross terms (48 TX/Rx combinations).

Response Amplitude Detection

Traditional anomaly selection is based almost entirely on signal response amplitude. The stated requirement of the task defined as detection of the smallest munitions of interest (e.g. 37-mm projectile) at its maximum depth of reliable detection. Using modeled response versus depth curves for a given sensor, and estimates of the site-specific noise levels, a set of maximum depths of reliable detection are derived for each munitions type identified in the CSM as a TOI. **Figure 1** presents an example of this process for a 37-mm projectile.

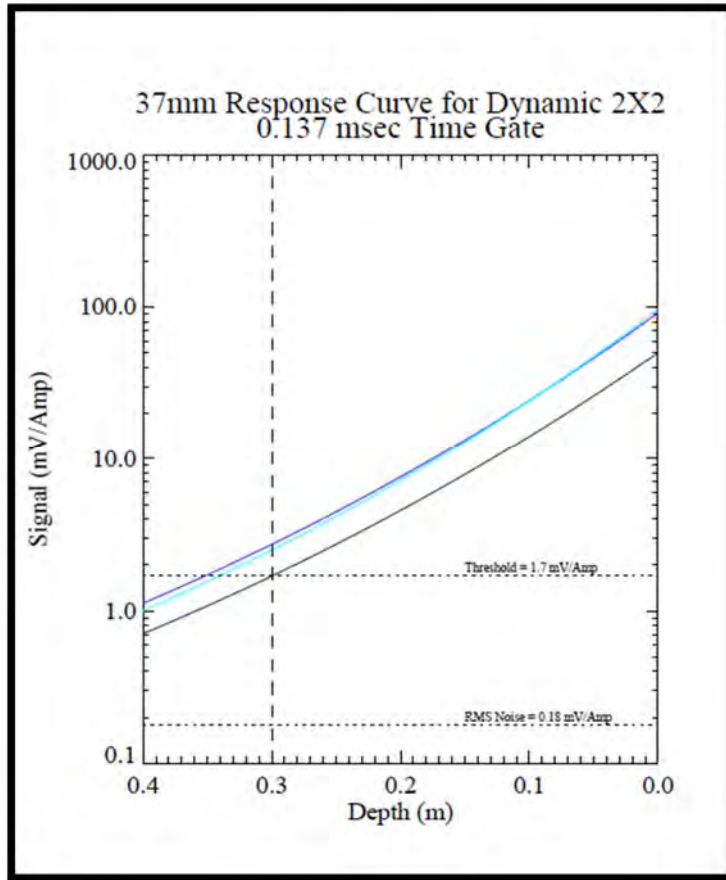


Figure 1

Response amplitude detection threshold for 37mm projectiles. The graph shows the minimum response amplitudes for three different types of 37-mm projectiles as a function of depth. An estimate of the noise (root mean square) of the background signal and the detection threshold are provided as dashed horizontal lines.

For amplitude response detection, the daily function tests verify the sensor signal response and a post survey assessment of the site-specific noise levels are used to verify that there was sufficient SNR to achieve the task objectives. Additionally the QC seeds are used to validate the detection performance of the system. A validation failure will result if any QC seeds located at or shallower than their maximum detection depth are not identified in the detection survey.

Dipole Response Filter Detection

Advanced Detection will also be used for anomaly detection that makes use of the rich data set output of the advanced sensors. This approach has been shown to have improved SNR performance (example depicted in **Figure 2**).

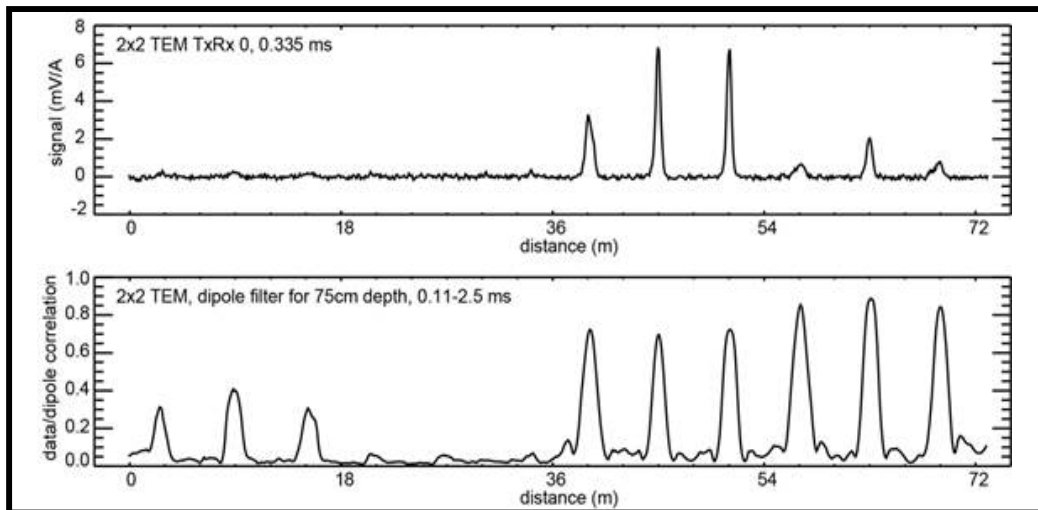


Figure 2

TEMTADS data collected along a line over a set of 60mm mortars at Blossom Point, MD by NRL. The targets at 75 centimeter (cm) depth are barely discernible in the noise for the 2x2 monostatic Z component response amplitude data. The bottom panel shows the advanced detection dipole filter output and the 75 cm deep mortar signals become clearly visible.

This target selection routine takes advantage of all the measured data, not just the monostatic Z component. Advanced Detection targets are selected using the following process:

- At every 0.1m grid node, the surrounding data (from a 1m x 1m box) are submitted to a dipole analysis inversion routine to determine the best match for a dipole located at that grid node. The match between the measured data and the derived dipole model (i.e. the fit coherence) is used to indicate the presence or absence of a discrete metal source at that location with a higher match to a dipole indicating the presence of a metal source.
- Peaks in the fit coherence metric are identified (similar to AR peaks) and a subset of data around this peak are then subjected to a more computationally expensive process whereby the data are inverted in separate passes for one, two, or three dipole sources, enabling spatial resolution of multiple sources within the footprint of the original dipole response region.
- Resulting sources are examined and culled (based upon size/decay metrics) to only sources that could be the smallest munition of interest (e.g. 37mm projectile) or larger and the thinnest-walled or thicker-walled munition of interest.
- Fit Easting (X) and Northing (Y) locations from the inversions were used as the source positions.
- Sources closer than 20 cm are merged into a single source and a target list was compiled based on the final positions of the sources.

The size is calculated as root sum square of the values of the three β s at 0.137 ms and expressed as a base 10 logarithmic exponent ($-1 = 0.1$, $0=1$, $1= 10\ldots$) and the decay is calculated as the size at 1.024 ms divided by the volumetric size 0.137. Size and decay are unit-less numbers. Example cut-off thresholds are presented on **Figure 3** along with example data and items selected from the library. The grey dots in this figure represent the targets deemed too small or too thin-walled to be possible TOI in this example.

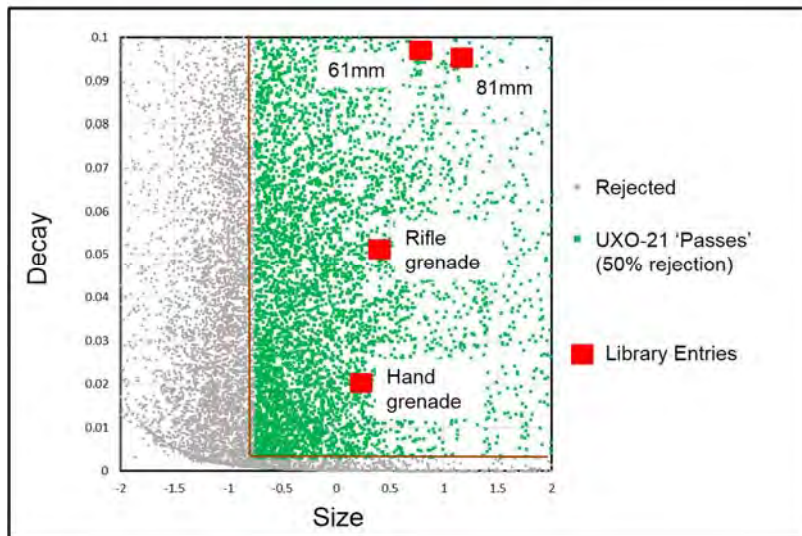


Figure 3

Example plot of size and decay values for AD targets juxtaposed with entries taken from a site-specific library.

Verification of the advanced detection thresholds is performed by ensuring that no TOI are discovered right at the threshold value – typically a set of 200 targets must exist between the last TOI and the thresholds used.

Library-match Threshold Verification

Classification will be based primarily on the goodness of fit metrics generated by the Geosoft Oasis Montaj UX Analyze module (UXA) during a comparison of the β values estimated for each surveyed target and the β values in the munitions library developed for the project. The goodness of fit metric indicates the fit correlation between a target and the best fit item in the library, with higher metrics indicating a better fit between the target and the corresponding item in the library. The library fit analysis will match the following four combinations of β s to those of the candidate library TOIs:

1. $\beta_1, \beta_1/\beta_2, \beta_1/\beta_3$
2. $\beta_1, \beta_1/\beta_2$
3. $\beta_1/\beta_2, \beta_1/\beta_3$
4. β_1

The average of these fit metrics will be combined to provide the 'decision metric.' This library matching process will be performed for each single-solver model and every target model in each of the multi-solver candidate realizations. For each flag position, the highest value decision metric (i.e. most likely TOI) from the combined set of single-solver and multi-solver targets will be used as the decision metric for that position.

A cut-off threshold will be determined based upon review of the decision metrics derived for the known targets (QC seeds, bench measurements, and training dig results). This threshold will be used to rank and classify the target list where values above the threshold will be considered TOI, and values below the decision metric will be considered non-TOI.

The threshold used to declare an anomaly as non-TOI will be confirmed by sampling through intrusive investigation beyond this threshold. The number of digs required to achieve this confirmation will depend to a large degree on the dig results – particularly the results for anomalies that were ranked just prior to the analyst cut-off threshold. Partial ROC curves showing a steep ascent early in the prioritized list (indicating most targets are TOI), followed by a small section of 'flat line response' indicating the absence of TOI in the latter part of the prioritized list are indicative of successful classification. Partial ROC curves that do not display a distinct inflection point between the TOI and non-TOI sections, and have TOI in close proximity (on the prioritized list) to

the cut-off threshold will require more verification digs. Current guidance suggests a minimum of 200 non-TOI results are found between the last TOI and the analyst threshold (stop dig point) to verify this threshold.

Feature Analysis Verification

Finally, additional verification digs will be performed to verify that the cut-off thresholds for feature space identification of potential TOI will be performed. Values related to size, axial symmetry and decay (longer decays are indicative of thick walled objects) are calculated from the β s. A set of verification digs will be derived to test the cut-off threshold used for each of these parameters. A verification failure will result if any TOI are found in the set of verification investigations.

Attachment E
Responses to Regulator Comments

**Responses to EPA Comments on the
Draft Uniform Federal Policy Quality Assurance Project Plan, Advanced
Geophysical Classification For Munitions Response Remedial Investigation
Dated March 2016**

**Atlantic Fleet Weapons Training Area – Vieques
Former Vieques Naval Training Range and
Former Naval Ammunition Support Detachment
Vieques, Puerto Rico**

Presented below are review comments on the *Draft Uniform Federal Policy Quality Assurance Project Plan, Advanced Geophysical Classification for Munitions Response Remedial Investigation – Vieques, Former Vieques Naval Training Range, Vieques, Puerto Rico*; dated March 2016 (hereinafter referred to as the QAPP).

GENERAL COMMENTS

1. Even though the transmittal message mentions the near-term nature of this QAPP, to be an attachment to the RI SAP for the roads (UXOs 3, 5, 6, 11), the document does not specify the site or sites where the Advanced Geophysical Classification (AGC) will be implemented nor the size of grids that will be established at each site. Revise the QAPP to include this information, or state that the noted information will be provided in the site-specific work plans and/or the related QAPPs.

Navy Response: AGC for MR RIs are currently planned for use within the one-acre sampling units for the roads (UXOs 3, 5, 6, and 11). The Master SAP and Master SAP Addendum 4 present the locations of the sampling units (generally four grids) where AGC will be used.

The following has been added at the end of the first paragraph within the Executive Summary and at the end of the first paragraph of Step 1 in Worksheet #11 of the AGC QAPP: “AGC use for MR RI activities will be conducted in accordance with this QAPP, the Master Sampling and Analysis Plan (SAP), East Vieques Terrestrial UXO Sites (CH2M, 2013), and Addendum 4, Master Sampling and Analysis Plan, UXOs 3, 5, 6, and 11 Remedial Investigation (CH2M, 2016).”

2. The discussion of target population in Worksheet #11, Project Quality Objectives, Step 4, Define the boundaries of the project, acknowledges that certain types of munitions can be effectively classified, but there are other types of munitions that cannot be classified for various reasons. For example, damaged munitions may no longer have the required symmetrical axes. These damaged munitions may contain high explosives (HE) or be fuzed, but would not be recognized because they are damaged and the signature would not match the library. In addition, asymmetric munitions like intact hand grenades would not be identified. Since asymmetric and damaged munitions would not be classifiable, they would not be placed on the target of interest (TOI) list or dug; and the related hazards would remain. This should be acknowledged as a limitation of advanced geophysical classification in the QAPP. Step 4 also states that flares, fuzes, and pieces of munitions items that mimic clutter cannot be classified, but it is unclear what percentage of the munitions at these sites is expected to be unclassifiable. The percentage of munitions items that mimic clutter should also be discussed. Revise the QAPP to discuss other types of munitions that may not be classifiable and acknowledge that the related hazards may remain. In addition, revise the QAPP to discuss the percentage of munitions items that mimic clutter that are expected in each area to be surveyed.

Navy Response: The objective is to identify targets of interest for the purposes of subsurface soil sampling, not to ensure all subsurface munitions items are removed. It is not relevant that some percentage of subsurface munitions may not be classifiable. Specifically, as discussed in the Executive Summary, Objective

and Overview of Use subsection, the objective of the AGC is to aid in the characterization of the nature and extent of MEC within the subsurface and collection of subsurface soil samples. The intent of the AGC is not to remove all potentially hazardous munitions, but to appropriately characterize the nature of the munitions in the subsurface and to prioritize the anomaly locations so that subsurface soil samples can be focused in the most conservative areas (i.e., targets of interest) and also reduce the number of intrusive investigations required. The current process used to locate subsurface soil samples is by DGM, where select anomalies are intrusively investigated based on the mV reading, shape of anomaly, clustered locations, etc. Then based on the findings of the intrusive investigation, subsurface soil samples are positioned in the most conservative areas to determine a potential release to the environment. Implementation of AGC techniques will enhance the positioning of subsurface soil samples at/adjacent to the most conservative areas (i.e., targets of interest).

The following has been added at the end of the first paragraph within the Executive Summary and at the end of the first paragraph of Step 1 in Worksheet #11: “The activities being performed in accordance to this document are limited to preferentially selecting targeted locations for intrusive investigation and subsequent munitions constituent (MC) sampling. As this is not a removal/remedial action, Advanced Geophysical Classification (AGC) with the intent of identifying anomaly locations that do not require removal is not a project objective.”

EPA Evaluation of Comment: The response partially addresses the comment. It is understood that the intent of the Advanced Geophysical Classification (AGC) is to characterize the nature of munitions in the subsurface rather than to remove all potentially hazardous munitions. However, the response failed to address the issue of munitions that cannot be classified. If munitions cannot be classified, they cannot be characterized. Therefore, it is relevant to consider the types and percentage of munitions that cannot be classified, including asymmetric and damaged munitions, which may contain high explosives (HE) and represent significant hazards. If unidentified, these munitions would not be identified for sampling. If these munitions cannot be identified by AGC, AGC has limited usefulness. The response also does not discuss the percentage of munitions items that mimic clutter. As requested in the original comment, revise the Uniform Federal Policy Quality Assurance Project Plan, Advanced Geophysical Classification for Munitions Response Remedial Investigation - Vieques, Former Vieques Naval Training Range and Former Naval Ammunition Support Detachment, Vieques, Puerto Rico (the QAPP) to discuss types of munitions that cannot be classified, and to acknowledge that if not investigated, the hazards associated with these munitions would remain. In addition, revise the QAPP to estimate the percentage of munitions items that mimic clutter at these sites.

Navy Response to Evaluation Comment: The TEMTADS is not being used to characterize the nature and extent of MEC – it is only being used to preferentially select MEC for MC sampling. The text in the executive summary erroneously stated:

“The objective of using AGC at the former VNTR and former NASD is to assist in characterizing the nature and extent of MEC, if present, in the subsurface.”

This text is corrected as follows:

“The objective of using AGC at the former VNTR and former NASD is to assist in characterizing the nature and extent of munitions constituents (MC), if present, in the subsurface.”

Because we are not characterizing the types of munitions, a detailed discussion of the limitations of AGC is not germane to the proposed use of the technology.

3. The standard operating procedure (SOP) checklists in Attachment B should include the requirement to explain “No” entries and space for these explanations. Revise the SOP checklists to require explanations of “No” entries.

Navy Response: A column has been added in SOP MR-AC-01-01 Attachment 1 entitled “If no, provide comment below.”

4. The many limitations of classification surveys should be acknowledged in the QAPP. In addition, it is possible that the mix of munitions and munitions components may be such that the classification surveys become ineffective at achieving the desired results and should be discontinued for the area involved. However, no mention of the criteria for this determination is provided in the QAPP. Revise the QAPP to discuss the limitations of classification surveys and the potential that classification is ineffective and the criteria that would be established to determine when the classification process should be discontinued.

Navy Response: As discussed in the response to General Comment #2 above, the project is not performing AGC in a manner where the TEMTADS sensor is being used to identify and remove all potentially hazardous subsurface metal (text has been added to the executive summary and Worksheet #11 for clarification), as may be done as part of a removal or remedial action. TEMTADS is being used solely to enhance and expedite the selection of locations with buried munitions for MC sampling. For past Vieques UXO site RIs, a magnetometer was used to identify subsurface anomalies. However, in those instances, all anomalies had to be dug to identify where subsurface samples would be collected. Use of AGC will simply permit the process to work more effectively by more readily identifying locations for subsurface soil sampling. In this manner, the approach can primarily investigate targets that are very high on the prioritized list (thus are very likely to be TOI) and will not approach the transition zone between TOI and clutter.

EPA Evaluation Comment: The response does not address the comment. Specifically, the original comment asked that the QAPP be revised to discuss the limitations of classification surveys, the potential that classification is ineffective (e.g., for damaged or asymmetric munitions), and the criteria that would be used to determine when AGC should be discontinued. Since munitions that cannot be classified could contain HE, a discussion of the limitations and effectiveness of AGC is important. As requested in the original comment, revise the QAPP to discuss the limitations of classification surveys and the potential that classification is ineffective and the criteria that would be established to determine when the classification process should be discontinued.

Navy Response to Evaluation Comment: As indicated in the previous response, TEMTADS is not being used to for classification. Text in the QAPP has been revised or removed, as warranted, to make this clearer. Therefore, a discussion of the limitations of classification surveys is not applicable. The only thing TEMTADS is being used for is to potentially reduce the number of anomalies that need to be dug up before selecting preferential targeted locations for intrusive investigation and subsequent MC sampling. The goals of the investigation are met regardless of the potential for missing any particular MEC item.

Additionally, asymmetric targets such as hand grenades are classifiable and damaged munitions only become less likely to be identified as munitions as their shapes deviate considerably from their original shapes (thus are much less likely to contain HE).

SPECIFIC COMMENTS

1. **Executive Summary, Page 4:** The Executive Summary states that intrusive investigations are not part of the AGC program, so data will not be used to classify targets (anomalies) as TOI or non-TOI. However, without intrusive investigations, it will not be possible to determine if AGC is effective at Vieques or to create a site-specific library. Since soil types and other site characteristics may cause the site-specific signature for a munition to vary from the library signature generated at another site, intrusive investigation is crucial to validate the AGC methodology at Vieques so that an iterative process can be used to create a site-specific library. It is illogical to conduct AGC at Vieques without intrusive investigation. Revise the approach described in the QAPP to include intrusive investigation to validate the classifications.

Navy Response: The Executive Summary does not state that intrusive investigations are not part of the AGC program. In fact, it talks about how the AGC will help to reduce the number of intrusive investigations necessary in order to meet the project objectives.

Please also see the response to General Comment #2. The library signatures are not site-specific – these signatures are intrinsic to the size, shape, and material composition of the item and signatures derived at other sites are valid for use at Vieques. The term ‘site-specific library’ refers to the selection of items that are in the library for a site-specific use, not the intrinsic features of the items - for example the conceptual model for a site may indicate that only 60 mm mortars and 81 mm mortars were used; thus, the library can be modified to include only these items for a site-specific project – but the signatures for these items do not need to be derived at the site.

2. **Worksheet #10, Conceptual Site Model, Page 21:** The success of this project depends on the accuracy of the conceptual site model (CSM), in part because the expected types of munitions and their condition is critical for data interpretation. Note that this is a key information input in Step 3 of Worksheet #11, Project Quality Objectives, and that Step 4 states that the list of munitions that were previously found is included in Worksheet #10. If any work has been done at the site since the CSMs was generated, the results should be used to update the CSM. Further, the CSM must be updated during the geophysical survey, data interpretation, and field verification (dig) process because if any unexpected munitions are found, the interpretation of results may have to be redone. In addition, the CSM should include the expected density of anomalies. Step 3 also indicates that topography, geology, and vegetation are important inputs. Provide updated CSMs in the site-specific work plans that include a list of expected munitions, as well as a description of topography, geology, and vegetation.

Navy Response: The agencies have reviewed the CSM, which is presented in the Master SAP and SAP Addendum, both of which were approved by the regulatory agencies.

EPA Evaluation Comment: The response does not address the comment because it does not discuss the issue of updating the conceptual site model (CSM). The success of AGC is dependent on having an up-to-date, comprehensive, and complete CSM, updating the CSM as unexpected munitions are identified, and for including topography, geology, vegetation, and the density of anomalies. Therefore, if any work has been done since the CSM was last updated, it should be updated to include the results of that work. As requested in the original comment, provide updated CSMs in the site-specific work plans that include a list of expected munitions, as well as a description of topography, geology, and vegetation. If no work has been done since the CSM was last updated, revise the QAPP to include such a statement and also to include the requirement to update the CSM during AGC if there are any unexpected findings.

Navy Response to Evaluation Comment: The QAPP is an addendum to separate Uniform Federal Policy Sampling and Analysis Plans (UFP-SAPs) for MC sampling and only addresses the use of the TEMTADS to preferentially select MEC for intrusive MC investigations. Any actionable results of the MC investigation are covered in their respective UFP-SAPs

3. **Worksheet #11, Project Quality Objectives, Step 4, Define the boundaries of the project, Page 25:** The characteristic of interest discussion indicates that derived target features will be compared to a site-specific library of munitions features, but it is unclear how the site-specific library was generated. If one of the tasks is to generate a site-specific library, the QAPP should be revised to include this task. Revise the QAPP to explain how the site-specific library was generated or include generation of this library as a task.

Navy Response: Please see the response to Specific Comment #1. The site-specific library will contain signatures for munitions that are anticipated to be present at the site, based upon the CSM. If there was a munition type in the CSM that does not have an existing library entry, measurements of an inert munitions type or surrogate could be made to derive a signature to be added to the library. This situation is not anticipated for the roads RI.

The following has been added at the end of the “Characteristics of interest” subsection: “The site-specific library will contain signatures for munitions that are anticipated to be present at the site, based upon the CSM.”

4. **Worksheet #11, Project Quality Objectives, Step 4, Define the boundaries of the project, Page 26:** The text indicates that Figure 11-1 includes “the estimated maximum depth of reliable detection for a selection of munitions from the CSM,” but this information should be provided for all of the munitions in the CSM. Revise the QAPP to include the estimated maximum depth of reliable detection for all expected munitions.

Navy Response: The figure provides estimates of maximum depth of reliable detection for a range of sizes of ordnance. These examples are appropriate for use to estimate maximum reliable depths of detection for similar sized ordnance. The following has been added after the sentence that refers to Figure 11-1: “These examples are appropriate for use to estimate maximum reliable depths of detection for similar sized ordnance.”

5. **Worksheet #11, Project Quality Objectives, Step 5, Develop the Project Data Collection and Analysis Approach, Page 28:** The first decision rule indicates that the target density will be used to evaluate whether cued analysis of individual anomalies can be done, but anomaly density is not one of the information inputs listed in Step 3, Information Inputs. Also, it is unclear how the target density will be determined or the (numerical) criteria will be used to determine if cued analysis can be done. Revise Worksheet #11 to include anomaly density as an information input. Also, revise the QAPP to discuss how the anomaly density will be determined and the criteria that will be used to determine if cued analysis can be done.

Navy Response: The QAPP has been revised accordingly. In Worksheet #11, Step 3, the following bullet was added under Data analysis results, including: “Anomaly density maps.” In addition, the “Dynamic Data Processing” bullet was removed.

The following has been added at the end of the first paragraph of Step 5: “Anomaly density maps will be derived using a 10 m² grid cell size and 1 m resolution. For each 1 m grid node, the number of anomalies in the surrounding 10 m² area will be counted and multiplied by 404.7 to provide the anomaly density in anomalies per acre.”

The first decision rule in the Cued Phase of Step 5 was revised as follows: “If a portion of the investigation area is determined to have an anomaly density greater than 3,000 anomalies per acres (too high for cued analysis of individual anomaly locations), then an....”

EPA Evaluation Comment: The response partially addresses the comment. Specifically, the basis for the factor of 404.7 for calculating the anomaly density should be provided. Revise the response and QAPP to provide the basis for the factor of 404.7.

Navy Response to Evaluation Comment: 404.7 is the factor required to convert 10 m² to one acre. This information has been added to the QAPP.

6. **Worksheet #11, Project Quality Objectives, Step 5, Develop the Project Data Collection and Analysis Approach, Page 28, and Worksheet #12, Measurement (Project) Performance Criteria:** The second decision rule in Step 5 under “Cued Phase” states that targets at the top of the prioritized target list will be preferentially selected for intrusive investigation/MC sampling, but several hundred targets should be chosen for data validation. The categories of additional targets should include sequential targets beyond the TOI and random targets selected from non-TOI anomalies. A decision rule is needed for these additional targets, because if any munitions and explosives of concern (MEC) are found, a root-cause analysis should be done to determine the corrective action(s). Further, the performance criteria for the data validation targets should be included in Worksheet #12, Measurement Performance Criteria, since no MEC should be found when the data validation targets are intrusively investigated. Revise the decision rules to include data validation using several hundred additional targets. In addition, revise Worksheet #12, Measurement (Project) Performance Criteria to include criteria for the data validation targets.

Navy Response: As discussed in the responses to the General Comment #2 and Specific Comment #1, validation is not required as AGC is only being used to help identify locations of subsurface soil samples. In other words, it is being used only to prioritize the dig list to gain efficiencies in finding MEC. It is not being

used to show that the targets left in the ground are non-hazardous; thus, there are no conclusions that require validation.

EPA Evaluation Comment: The response does not address the comment. Validation should always be part of an AGC survey. In this case, it is essential because there could be locations that should be sampled beyond the target of interest (TOI) anomalies selected for sampling to ensure that munitions and explosives of concern that should be sampled are identified. Further, a decision rule for this case is necessary. As requested in the original comment, revise the decision rules to include data validation using several hundred additional targets. In addition, revise Worksheet #12, Measurement (Project) Performance Criteria to include criteria for the data validation targets.

Navy Response to Evaluation Comment: As indicated previously, this is not an Advanced Geophysical Classification (AGC) survey. There will be no actionable “cut-off threshold;” therefore, threshold validation is not required. Additionally, there is no necessity to validate the TEMTADS results because the MC sampling process provides all of the validation required to meet the goals of the study.

7. **Worksheet #12, Measurement (Project) Performance Criteria, Page 29:** As the number of subsurface seeds that will be placed in each area or grid is not specified, a statement that this will be noted in the site-specific QAPP and/or work plan should be included in Worksheet #12. Note that because AGC is not yet a proven technology, multiple seeds buried in different orientations and at different depths are necessary. Further, it appears that the specification indicates that this will be based on the number of industry standard objects (ISOs) and inert items that are available for use. This should not be a limiting factor, and sufficient ISOs and inert items for use as seeds should be obtained. Revise the QAPP to address each of these issues.

Navy Response: As presented in Worksheet #12, the number of subsurface seeds will be sufficient to ensure that an average of 1 seed shall be encountered for every team day of dynamic and/or cued survey. While the number of inert munitions seeds may be limited by availability, the number of ISOs and thus total number of seeds will have no such limitation. Text has been added to clarify this.

8. **Worksheet #14 & 16, Project Tasks & Schedule, Page 35 and Worksheet #17, Survey Design and Project Work Flow, Pages 37-38:** Worksheet #17 includes tasks that are not listed in QAPP Worksheet #14 & 16. For example, Worksheet #17 includes TOI digs, which are essential for the AGC process, since unexpected MEC items that are found must be input into the CSM in order to evaluate the data processing and classification. Ensure that all project tasks are included in both worksheets.

Navy Response: Please see the response to General Comment #2.

EPA Evaluation Comment: The response does not address the comment. A reference to the response to General Comment 2 does not address the comment. Review and address the original comment, which asked that Worksheets #14 & 16 and #17 be revised to include all project tasks.

Navy Response to Evaluation Comment: Worksheets have been modified to remove intrusive investigation as a task. The intrusive investigation activities are covered in the MC sampling UFP-SAP.

9. **Worksheet #17, Survey Design and Project Work Flow, Section 2.0, Site Preparation, Pages 40-41 and Worksheet #31, 32 & 33, Assessments and Corrective Actions, Page 63:** It is unclear why vegetation removal (e.g., cutting grasses, removing other vegetation that may obstruct the geophysical surveys) is not included under site preparation. Vegetation removal will likely be required so that the TEMTADS sled or wheeled version has a clearance height of a few inches, based on Section 3.2 (Instrument Verification Strip Construction), item 4 on Page 5 of 8 in SOP MR-AC-02-01. Revise the Site Preparation Section and Worksheet #31, 32 & 33 to include vegetation removal or explain why this is unnecessary.

Navy Response: The QAPP covers the use of TEMTADS in support of the RI. Please refer to the Master SAP and SAP Addendum for the various activities associated with the RI.

EPA Evaluation Comment: The response does not address the comment, which involved vegetation removal, not the TEMTADS survey. As requested in the original comment, revise the Site Preparation Section and Worksheet #31, 32 & 33 to include vegetation removal or explain why this is unnecessary.

Navy Response: Vegetation cutting is incidental to the task, not an integral component of TEMTADS survey; therefore, it is not necessary to include that information in the various worksheets.

- 10. Worksheet #17, Survey Design and Project Work Flow, Section 3.2 Subsurface Quality Control Seeding, Pages 40-41:** Subsurface seeds should be placed in a variety of orientations as well as at different depths. Revise the text to require placing subsurface seeds in a variety of orientations.

Navy Response: The following has been added to the end of the second paragraph in Section 3.2: “The orientation of the seeds will also be varied.”

- 11. Worksheet #17, Survey Design and Project Work Flow, Section 3.4, Establish Instrument Verification Strip, Page 42:** The minimum number of seeds that will be placed in the instrument verification strip (IVS) should be specified, or a notation that this will be presented in the site-specific QAPP and/or work plan should be included. Section 5, Dynamic Detection Survey, appears to indicate that 2 ISOs will be used, but this is insufficient for the cued survey IVS, based on Section 3.2, Instrument Verification Strip Construction of SOP MR-AC-05-01. This SOP indicates that multiple IVS items, including a blank, should be installed at 5 meter intervals and also states that inert items should be used if possible. Ideally, IVS construction should be suitable for both the dynamic detection surveys and the cued survey. Revise the QAPP to consistently specify the number of each type of seed and blanks that will be placed in the IVS and explain why this number of seeds and blanks is sufficient. If this will differ depending on the conditions noted at each site, a statement to this effect should be included.

Navy Response: In practice, the IVS is typically constructed to support the static cued survey as well as the detection survey (i.e. it is constructed in accordance with SOP MR-AC-05-01). The different approaches are specified in case the two surveys (for some reason) use separate IVS set-ups or locations. The details as described are sufficient to meet the goals of the IVS for each survey. Therefore, no changes to the QAPP are warranted.

EPA Evaluation Comment: The response does not address the comment. Specifically, the number of seeds and blanks that will be placed in the instrument verification strip (IVS) should be sufficient for each type of survey that will be conducted. Therefore, it appears that the criteria included in Section 3.2, Instrument Verification Strip Construction of SOP MR-AC-05-01 (which indicates that multiple IVS items, including a blank, should be installed at 5 meter intervals, including inert items), should be included in Section 3.4 of Worksheet #17. Revise Worksheet #17 to specify the number and types of seeds and blanks (i.e., as specified in SOP MR-AC-05-01) that will be placed in the IVS.

Navy Response to Evaluation Comment: The text has been modified as suggested.

- 12. Worksheet #17, Survey Design and Project Work Flow, Page 37:** Worksheet #17 does not include establishing the background areas that must be surveyed every 2 hours, as specified in Worksheet #12. These background areas will presumably be established in each survey area so that it does not take much time to collect the necessary measurements. In addition, revise the QAPP to discuss how the background data will be used. It should be noted that Figure 17-1 includes selecting background locations. Revise Worksheet #17 to include establishing background areas, the criteria for these areas, and to include procedures for conducting background measurements. Also, revise the QAPP to discuss how the background data will be used.

Navy Response: Please note that the establishment of background areas along with the criteria, procedures, and use of the background data are included in SOPs MR-AC-06-01 and MR-AC-07-01, referenced in Worksheet #17 and Figure 17-1 (DFW 8 and 9). However, for further clarification, the following was added in the DFW 8 second column: “Reacquire and flag anomaly and potential background locations, verify

background locations (MR-AC-06-01)..." and in Section 8.2: "Prior to conducting cued surveys, potential background locations identified during the dynamic data processing will be measured, processed, and verified for usability as cued background locations. These locations will be checked in accordance with SOP MR-AC-06-01 (see Attachment B). Each background flagged location will have cued measurements performed over the center and offsets at a ½ cart width in each cardinal direction. The set of 5 measurements will be processed and validated through a comparison criteria detailed in SOP MR-AC-06-01, and the results will be documented and presented as part of the QC documentation. Background locations will be spaced throughout the survey area so that they are easily accessible by survey teams and reflect localized site conditions. Background measurements will be taken approximately every 2 hours, and after any significant changes to field conditions (i.e., immediately following a rain storm) or equipment (i.e., new field tablet)."

In addition, the following was added in Subsection 10 of Worksheet #17 after the first sentence:

"Background corrections collected during the cued phase will be used to remove the sensor self-signature and soil response from the measured target data. Background corrections will be applied using the closest background (chronologically and spatially) and within approximately 2 hours of the target measurement."

- 13. Worksheet #22, Equipment Testing, Inspection, and Quality Control, Table 22-1, Dynamic Survey, (Instrument TEMTADS), Page 49:** The size and decay rate threshold verification (for Advanced Detection) entry does not include a responsible person/report method, nor a person who will do verification, nor the failure response. In addition, it is unlikely that cued data analysis will be able to confirm that 100 percent of excluded anomalies are non-TOI. Intrusive investigation is necessary to confirm that excluded anomalies are non-TOI. Revise the acceptance criteria to acknowledge that intrusive investigation is necessary to make this confirmation.

Navy Response: Please see the response to General Comment #2. Verification/validation of the results is achieved by the intrusive investigation results – there is no requirement to validate the results for detected targets that are not intrusively investigated. Therefore, no changes to the QAPP are warranted.

EPA Evaluation Comment: The response does not address the comment. Review the original comment and revise the size and decay rate threshold verification (under Advanced Detection) entry in Worksheet #22 to specify the responsible person/report method, the person who will do the verification, and the failure response. In addition, revise the acceptance criteria to acknowledge that intrusive investigation is necessary to confirm that excluded anomalies are non-TOI.

Navy Response to Evaluation Comment: As indicated in previous responses, it does not matter to the goals of the survey if some of the excluded anomalies are TOI. The goal is to preferentially select anomalies that are TOI, not identify all TOI. Reasonable thresholds will be used but validation of these thresholds is not necessary, as discussed previously.

This MQO has been modified to specify only that appropriate thresholds are used, as determined by the data processing geophysicist, reported in the Contractor QC report and verified by the QC geophysicist.

- 14. Worksheet #22, Equipment Testing, Inspection, and Quality Control, Table 22-3, Cued Survey (Instrument: TEMTADS; Classification Tool: UX-Analysis), Pages 53-54:** Table 22-3 is missing a measurement quality objective (MQO) for verifying that the classification tool correctly separates TOI from non-TOI anomalies. Revise Table 22-3 to include this MQO.

Navy Response: Please see the response to General Comment #2. An MQO assessing the TOI vs not TOI is not necessary based on the RI objectives.

- 15. Worksheet #22, Equipment Testing, Inspection, and Quality Control, Table 22-4, Intrusive Investigation, Page 55:** Table 22-4 should include MQOs for reacquiring and investigating "cannot analyze" anomalies, since a certain percentage of these must be intrusively investigated to ensure that the classification tool is functioning effectively. Revise Table 22-4 and other worksheets as necessary to include these MQOs.

Navy Response: Please see the response to General Comment #2. For an AGC survey conducted for a removal or remedial action, all anomalies categorized as “cannot analyze” would be intrusively investigated. For the RI, these would simply be treated as if no classification was performed (i.e., will not be intrusively investigated) because the classification results are by definition invalid – thus no MQOs specific to this category are necessary.

- 16. Worksheet #29, Data Management, Project documents, and Records, Part 2, Control of Documents, Records, and Databases, Page 60:** Part 2 should include the intrusive investigation database, including field notes and photographs. Revise Worksheet #29 to include records and databases generated during field investigation.

Navy Response: The comment refers to record-keeping as part of the RI sampling/characterization. Please refer to the Master SAP and Master SAP Addendum for the procedures that will be followed.

EPA Evaluation Comment: The response does not address the comment. It is unlikely that the Master Sampling and Analysis Plan (SAP) includes all of the items that are appropriate for AGC. As requested in the original comment, include the intrusive investigation database, field notes, and photographs under Part 2 to ensure that data critical to AGC is maintained.

Navy Response to Evaluation Comment: The TEMTADS is being used in support of the SAP only and is not being used for AGC. Intrusive investigation is not being performed under this QAPP; it is covered in the MC SAP.

- 17. Worksheet # 31, 32 & 33, Assessments and Corrective Actions, Page 69:** The Conduct Validation Seeding, QC Seeding, and Construct IVS DFW does not note that the placement of surface seeds prior to the surface sweep should include anomaly avoidance techniques to ensure that those placing the seeds in an unswept area do not come into contact with MEC. Revise the cited DFW to include a statement concerning the employment of anomaly avoidance techniques in areas that have not been cleared of surface MEC.

Navy Response: Seeding will be similar to techniques used for DGM activities, in accordance with the Master SAP and SAP Addendum.

- 18. Worksheet #31, 32 & 33, Assessments and Corrective Actions, Page 63:** This worksheet is missing assessments and corrective actions for intrusive investigations. Revise Worksheet #31, 32 & 33 to include intrusive investigations.

Navy Response: Please refer to the Master SAP and SAP Addendum for applicable corrective actions associated with the investigation.

- 19. Attachment B, Standard Operating Procedures, MR-AC-05-01, Perform Initial Cued Instrument Verification Strip (IVS) Survey – TEMTADS (CH2M), Section 3.2, Instrument Verification Strip Construction, Page 5 of 7:** Item 5 includes procedures for conducting IVS measurements if the IVS is constructed on a slope, but measurements made on a slope will have positional bias that must be corrected. To the extent possible, each IVS should be constructed on flat land. Alternatively, procedures for measuring the degree of slope and correcting positional bias should be included in this SOP, if the processing software does not use the sensor’s inertial measurement unit data to correct for this error. Revise the SOP to require constructing each IVS on flat land or include procedures for measuring the slope angle and correcting positional bias if the processing software does not make this correction automatically.

Navy Response: The positioning software incorporates the sensor attitude – no change in the SOP is warranted.

- 20. Attachment B, Standard Operating Procedures, MR-AC-06-01, Perform Cued Surveys with TEMTADS (CH2M), Section 3.1, Target and Background Location Marking, Page 2 of 6:** This section states that background locations “will be staked out according to SOP MR-AC-08-01,” but the SOP MR-AC-08-01 methodology for using a single non-metallic flag does not appear to be appropriate for marking background location. A minimum of two and preferably three non-metallic flags should be used to mark the corners of

each background location so that the TEMTADS can be positioned quickly and accurately each time a background measurement is necessary. Further, the details for determining if an area is suitable as a background location are included in SOP-MR-AC-06-01, so the methodology for marking this location should be included. Revise SOP MR-AC-06-01 to include the methodology for marking background locations.

Navy Response: Use of a single flag for marking of background locations is appropriate –single flags to mark all cued investigation measurement locations is common. No change to the QAPP is warranted.

- 21. Attachment B, Standard Operating Procedures, MR-AC-06-01, Perform Cued Surveys with TEMTADS (CH2M), Section 3.5, Cued Target Anomaly Survey, Page 4 of 6:** The procedures for navigating to and collecting measurements at a marked anomaly do not state that metal pin flags should be removed before sensor measurements are collected to avoid spurious data. Revise this SOP to require removal of metal pin flags or explain how anomalies related to pin flags will be identified and removed from the data set.

Navy Response: These SOPs call for use of non-metallic pin flags, which do not have to be removed before sensor measurements.

- 22. Attachment B, Standard Operating Procedures, MR-AC-07-01, Process Cued Surveys with TEMTADS (CH2M), Section 3.4, Classification, Pages 4 and 5 of 7:** Section 3.4 should discuss identification of seed items and how seed items will be identified on the target list. Seed items should be included in the site-specific library. All potential seed items should be intrusively investigated, but seed items should not impact the number of items on the priority TOI list. Revise SOP MR-AC-07-01 to discuss the identification of seed items, how they will be identified on the target list, and to state that the number of priority TOI will be independent of the number of seed items.

Navy Response: Seed items are considered TOI and are always placed in the site-specific library. Seed items are blind to the processor/analyst thus only need to be identified as a TOI by the analyst, not specifically as a seed. The seeds also remain blind to the intrusive investigation team to allow QC of the entire process. For the purposes of this QAPP, results against seed do not need to be evaluated to validate the technology, because the intrusive results will serve as validation (these results provide the proof that sampling occurred at the locations of appropriate buried munitions items required by the MC sampling plan).

- 23. Attachment B, Standard Operating Procedures, MR-AC-07-01, Process Cued Surveys with TEMTADS (CH2M), Section 6.0, Reporting, Page 7 of 7:** The fourth item of the cued data sets assembly package list includes “Error! Reference source not found.” Revise this SOP to include the missing information.

Navy Response: The SOP has been edited to provide the correct link.

- 24. Attachment B, Standard Operating Procedures, MR-AC-21-01, Production Area Quality Control Seeding (CH2M), Table 1, Production Seed Burial Parameters, Page 4 of 6:** A single blind seed per day does not appear to be sufficient, and the method of calculating the number of seeds depends on the number of expected anomalies (targets). This approach appears unimplementable, since seeds should be placed before dynamic surveys are conducted and the number of anomalies can only be determined from the dynamic surveys. It would be preferable to specify an absolute number of seeds that must be placed in each area (e.g., 100 seeds for areas with less than 25 grids, 200 seeds for 25 to 50 grids), then divide that number by the number of grids in the area to determine the number of seeds that should be placed per grid. Note that the number of seeds should be sufficient to test the dynamic surveys, cued surveys, and anomaly classification, so more than one seed per grid is necessary. Revise Table 1 and the associated checklist to specify the total number of seeds that must be placed per area and the number of seeds per grid regardless of the number of anomalies.

Navy Response: Seeds need to be emplaced prior to conducting the survey. The minimum number of blind seeds will be equal to the number of anticipated team days required to complete the dynamic survey – in areas where a higher target density is expected, the number of seeds will be increased such that one seed per cued team day (as estimated prior to the dynamic survey) is encountered. This approach is standard to

the industry and sufficient to meet the goals of using blind seeds. Additionally it is not evident that the use of blind seeds is even required – the intrusive results will be sufficient to meet the goals of the investigation (i.e., targeted anomalies will be intrusively investigated until enough buried munitions locations have been discovered to meet the sampling requirements).

- 25. Attachment B, Standard Operating Procedures, MR-AC-22-01, Surface Clearance (CH2M), Section 7, References, Page 5 of 6:** The reference noted as “DDESB TP-18, Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel, December 2004” has been replaced by “DDESB TP-18, Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities, July 2015.” Correct the noted reference in Section 7 and in the first bullet of Section 3.1, Personnel and Qualifications.

Navy Response: Revised as requested.

- 26. Attachment D, Draft Validation Plan:** A critical element for an AGC data validation plan is the verification digs and corrective actions if a verification failure occurs, but specific details for this element are not included. For example, the number of additional verification digs should be specified. Typically, several hundred targets should be chosen for data validation. The categories of additional targets should include sequential targets beyond the TOI and random targets selected from non-TOI anomalies. If any MEC (TOI) are found in either set of targets, a root-cause analysis should be done to determine corrective actions. Revise the Data Validation Plan to include the number of sequential targets beyond the TOI and random non-TOI anomalies for verification dig and the actions that will be taken if TOI are found during the verification digs.

Navy Response: Please see the response to General Comment #2.

Responses to PREQB Comments on the Draft UFP QAPP for Advanced Geophysical Classification for Munitions Response Remedial Investigations at the Former Vieques Naval Training Range, Puerto Rico

1. Worksheet 9 should be updated to include the recent April 2016 Project Team meetings in New York City where the use of advanced geophysical classification to select locations likely to have MEC for the purpose of increasing the efficiency of MC sampling was presented and discussed.

Navy Response: Worksheet #9 has been updated to include the TEMTADS topic meeting minutes related to the April 2016 Technical Subcommittee Meeting.

2. SOP MR-AC-06-01 for performing cued classification data collection doesn't contain QC checklists. This is a major deviation from the DoD example classification QAPP that has been distributed as a template for contractors performing advanced geophysical classification. Although the reason for not including QC checklists is explained in the SOP, this deviation in this important SOP from the DoD example QAPP is not recommended. Consider using the QC checklist from the example QAPP to maintain consistency with the DoD guidance, especially as advanced geophysical classification is in the initial stages of implementation on the Vieques project.

Navy Response: The QC Checklist has been added to SOP MR-AC-06-01 Cued Geophysical Data Collection as an attachment.

**Responses to PRDNER Comments on:
Vieques NPL, Draft Uniform Federal Policy – Quality Assurance Project Plan
(UFP – QAPP), Advanced Geophysical Classification for Munitions Response
Remedial Investigations
Comments Made by PRDNER on June 14, 2016**

While holding the rest of our comments on the QAPP in reserve at this time, DNER requests that the Executive Summary be revised to state explicitly that this QAPP in its current form applies only to geophysical investigations associated with continued surface and subsurface clearance of the roads in the VNTR (specifically UXOs 3, 5, 6, and 11), and that appropriately revised site-specific UFP-QAPPs addressing Advanced Geophysical Classification will be submitted for regulators' review in support of future investigations as needed. In addition, if work in areas outside the roads is contemplated under the current QAPP, then please let me know, as DNER has comments specific to natural resource protection that we can send.

Navy Response: The Executive Summary has been edited as requested. Future UFP-QAPPs addressing Advanced Geophysical Classification will be submitted to regulators for review. Also, the agencies will be notified if work is done outside UXOs 3, 5, 6, and 11 under this QAPP.